

**“SUCCESSION OF RICE PEST COMPLEX AND
TESTING OF DIFFERENT MANAGEMENT MODULES
AGAINST RICE PEST COMPLEX UNDER SOUTH
GUJARAT CONDITION”**

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Succession of rice pest complex and testing of different management modules against rice pest complex under South Gujarat condition

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ABSTRACT

Rice (*Oryza sativa* L.) is the world's second most important cereal crop and a staple food crop of India. South Gujarat engage maximum rice growing area of the State belonging to Dang, Valsad, Navsari and Surat districts. In South Gujarat region, where warm and humid climate exists throughout the year, the prospective of productivity of high yielding varieties still not fully exploited due to number of biotic and abiotic factors. Among these, rice crop is mainly affected by many insect species starting from seedling to maturity stage and out of which, about 20 insect pests have economic importance. For the management of rice insect pests, farmers are using indiscriminate doses of chemicals which have created number of problems. Adoption of integrated pest management is one of the best strategies to overcome these problems.

The awareness regarding time of appearance of pest and period of its maximum activity helps the farmers to implement preventive and effective management practices. With this view, research work on the study of seasonal incidence, varietal screening and effectiveness of insecticides against yellow stem borer, *S. incertulus* of paddy as well as evaluation of different management modules against rice pest complex under South Gujarat conditions were carried out at Wheat Research

Station Farm, N.A.U., Bardoli during consecutive *Kharif* season of 2012 and 2013.

An experiment on the influence of different planting methods on succession of major pests of rice was carried out in rice field. This experiment was carried out with conventional (Transplanting) and SRI method of paddy cultivation. Under conventional method, yellow stem borer infestation appeared peak during first week of September (5.58% DH) and 1st week of October (5.79% WEH). In SRI method, the peak incidence was observed during first week of September (4.19% DH) and at last week of September (4.93% WEH). The results of both methods indicated that the weather parameters had less influence on the activity yellow stem borer infesting paddy.

Rice green leaf hopper, *N. virescens* incidence under conventional method of planting showed maximum hill damage (2.39%) and population of nymph and adults (12.05/hill) during first week of October (40th SMW). The incidence data under SRI planting revealed peak hill damage (2.13%) and population of nymph and adults (8.73/hill) during first week of October (40th SMW). The coefficient correlation results revealed that the maximum temperature and bright sunshine hrs influence the occurrence of green leaf hopper positively, while minimum temperature and relative humidity showed their negative effect.

Rice brown plant hopper, *N.lugens* recorded peak hill damage (2.82%) and nymph and adults population (3.17/hill) during first week of October (40th SMW) under conventional method. Whereas under SRI method, the highest hill damage (2.42%) and population (2.54/hill) was observed during last week of September (39th SMW). The co-efficient correlation revealed that the maximum temperature and bright sunshine hrs influence the damage of the brown plant hoppers positively, while minimum temperature and relative humidity showed negative impact.

Rice earhead bug, *L. acuta* incidence in conventional method of planting revealed maximum population of nymph and adults (10.03/5 net sweep) and (8.90/5 net sweep) in SRI method during first week of

October (40th SMW). The correlation data indicated that the maximum temperature and bright sunshine hrs positively control the population of earhead bug, while minimum temperature and relative humidity showed their negative influence.

The data on seasonal occurrence of leaf folder, *C. medinalis* revealed that the peak level reached during 4th week of September (39th SMW) when leaf damage due to leaf folder was 2.30% under conventional method and 2.66% under SRI method. The correlation results under conventional and SRI method indicated that the weather parameters had less impact on leaf folder damage.

Rice blue beetle, *L. pygmaea* data recorded in conventional method of planting showed that the highest leaf damage (2.75%) and the population of adults (2.41/plant) was reached at last week of August (35th SMW). Under SRI method, the peak leaf damage (2.30%) and the population of adults (2.31/plant) was also observed at last week of August (35th SMW). The coefficient correlation data revealed that bright sunshine hrs only affect the leaf damage and the population of the blue beetle negatively.

The results on number of sheath mites showed that maximum mite incidence was reached during the first week of October (40th SMW) under conventional planting method (18.04/leaf sheath) as well as in SRI method (11.95/leaf sheath). The two years data indicated that the maximum temperature and bright sunshine hrs positively affected the population of the sheath mite, while minimum temperature and relative humidity showed negative effect.

The higher damage of rice pest complex was observed in conventional method (transplanting) of planting than SRI method except in leaf folder indicated less efficiency of SRI method to reduce the leaf folder damage.

The data on abundance of spiders indicated that the peak spider activity was attained during 1st week of October (40th SMW) in

conventional method (4.36/hill) as well as in SRI method (4.54/hill). The correlation data showed that the maximum temperature and bright sunshine hrs positively influence the population of the spider, while minimum temperature showed their negative impact on the population built up of spider.

The egg parasitism of yellow stem borer by the Eulophid, *Tetrastichus schoenobii* was initiated after the start of yellow stem borer damage and reached highest during heading to flowering and noticed up to 33.04% under conventional method and 38.10% under SRI method in second week of September (37th SMW).

The larval parasitism results under conventional method showed that the parasitism of yellow stem borer by *Apanteles* sp. was peak during second (21.59%) and fourth week of September (19.44%). The data under SRI method revealed that the highest larval parasitism during second (31.67%) and fourth week of September (28.57%). Under conventional method, the larval parasitism of leaf folder (33.18%) by *Apanteles* sp. was observed during first week of October (40th SWM), which was also recorded under SRI method (27.88%).

Keeping in view of the economic importance of major insect pest complex of paddy, eighteen varieties were screened in field condition against major insect pests including mite during *Kharif* 2012 and 2013.

The incidence of yellow stem borer was recorded at 30 and 50 days after transplanting (DAT) for dead hearts showed that varieties *viz.*, GR-103, Gurjari and Masuri were found resistant (R), whereas varieties *i.e.* GR-102, GR-104 and GR-101 were graded as susceptible (S) against yellow stem borer. GR-12 and GR-11 variety proved as highly susceptible (HS). At heading stage (15 days before harvesting), white earhead per cent infestation of the varieties *viz.*, Masuri, Gurjari and GR-103 were showed resistant (R) category. While, varieties *viz.*, GR-104, GR-102 and GR-101 were graded as susceptible (S) against yellow stem borer. Variety GR-12 and GR-11 proved as highly susceptible (HS).

The findings on per cent hill damage due to green leaf hopper indicated that GR-101, GR-102, GR-103, and GR-104 found resistant (R) and recorded per cent hill damage between 1 to 10%. While, variety IR-28, GR-11 and Masuri were categorized as susceptible (S) as well as Gurjari and Jaya were grouped into the highly susceptible category (HS).

The results on per cent hill damage due to brown plant hopper showed that GR-101, GR-102, GR-103, GR-104 considered as resistant (R), while varieties *viz.*, IR-28, GR-11 and Masuri categorized as susceptible (S) and the two varieties *viz.*, Jaya and Gurjari considered as highly susceptible (HS).

The data on per cent damaged grains per panicle due to earhead bug revealed that the varieties *viz.*, GR-104, GAR-1, GNR-3, IR-22, GR-102 and GAR-2 found moderately resistant (MR). Whereas, IR-28 found susceptible (S) and Jaya was categorized into highly susceptible (HS).

The findings on per cent leaf damage due to leaf folder showed that varieties like GR-102, GR-103 considered as resistant (R). However, the variety GR-101 found susceptible (S) and varieties considered as highly susceptible (HS) were GR-12, Jaya, GR-104 and Masuri.

The results on per cent leaf damage due to blue beetle revealed that 7 varieties *viz.*, GAR-1, GR-102, IR-22, GAR-2, GR-103, GNR-2 and GR-104 are considered as resistant (R). However, varieties *viz.*, Masuri, Gurjari and Jaya considered as susceptible (S) while the variety Jaya was considered as highly susceptible (HS).

The population data of mites revealed that only 2 varieties *i.e.* Masuri and IR-28 are found promising varieties, while six varieties recorded moderate population and grouped into moderately susceptible were IR-22, GR-12, GR-103, Narmada, GNR-2 and NAUR-1. However, varieties considered as highly susceptible were Gurjari and Jaya.

The average data on per cent dead hearts due to different insecticides tested against rice yellow stem borer was recorded at 3, 7 and 10 days after first and second spray and revealed significant results

at each level. The similar trends of insecticide performance against yellow stem borer was observed with significant data during both spray schedules. The minimum damage was recorded fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃). The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) were at par with each other and also showed significantly lower damage than control. The yield data of paddy showed significant findings. The average highest yield (59.04 q/ha) was obtained in fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃) (57.21 q/ha) and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) recorded 51.71 and 50.33 q/ha yield, which found at par with each other and also showed significantly higher yield over control (43.79 q/ha).

The results after evaluation of different modules comprising various IPM practices against yellow stem borer, green leaf hopper, brown plant hopper, leaf folder and blue beetle at different interval showed significant results.

The different modules were tested against yellow stem borer and results were recorded at 30, 50, 60 and 70 days after transplanting (DAT) showed the significantly minimum dead heart damage in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module). The next effective module was Module IPM-II (non-chemical based module) and found comparable with Module IPM-IV (spot application). The highest dead hearts damage was recorded in Module IPM-V (farmer's practices).

The performance of different modules against green leafhopper was recorded at 50, 60 and 70 DAT indicated lowest hill damage in Module IPM-III (chemical + non-chemical based module) and showed comparable results with Module IPM-I (chemical based module). The significantly effective performance was also found in Module IPM-IV (spot application), followed by Module IPM-II (non-chemical based module). The highest hill damage was found in Module IPM-V (farmer's practices).

The different modules tested against brown plant hopper at 50, 60 and 70 DAT showed lowest hill damage in Module IPM-III (chemical + non-chemical based module), but found at par with Module IPM-I (chemical based module). The next effective module was Module IPM-IV (spot application) and Module IPM-II (non-chemical based module). The highest hill damage was found in Module IPM-V (farmer's practices).

The results on leaf damage caused due to leaf folder at 50, 60 and 70 DAT showed significantly lowest leaf damage in Module IPM-III (chemical + non-chemical based module) followed by Module IPM-I (chemical based module). The next effective module was Module IPM-IV (spot application), but showed similar results with Module IPM-I. Module IPM-II (non-chemical based module) recorded significantly lower damage than Module IPM-V (farmer's practices).

The data on infestation caused due to blue beetle at 30, 50 and 60 DAT revealed significantly lowest leaf damage in Module IPM-III (chemical + non-chemical based module). The next best modules were Module IPM-I (chemical based module), Module IPM-IV (spot application) and Module IPM-II (non-chemical based module), which showed significantly lower damage than Module IPM-V (farmer's practices).

The yield performance of different modules revealed the significant highest yield (61.25 q/ha) in Module IPM-III (chemical + non-chemical based module). The next effective modules were Module IPM-I (chemical based module) and Module IPM-IV (spot application) with 56.13 and 54.75 q/ha yield, respectively. Module IPM-II (non-chemical based module) (49.42 q/ha) recorded significantly higher yield over Module IPM-V (farmer's practices) (43.71 q/ha). The economics of different modules showed that Module IPM-IV (spot application) gave highest benefit cost ratio of 11.35 followed by 4.43 Module IPM-III (chemical + non-chemical based module), 3.06 in Module IPM-I (chemical based module) and 2.02 in Module IPM-II (non-chemical based module) over Module IPM-V (farmer's practices).



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C E R T I F I C A T E

This is to certify that the thesis entitled
“**Succession of rice pest complex and testing of
different management modules against rice pest
complex under South Gujarat condition**” submitted
by **Mr. Kakde Amol Madhukar** in partial fulfilment of
the requirements for the award of the degree of **Doctor
of Philosophy** in the discipline of **Agricultural
Entomology** of the Navsari Agricultural University is a
record of bonafide research work carried out by him
under my guidance and the thesis has not previously
formed the basis for the award of any degree, diploma
or other similar title.

Place: Navsari

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Date: 2nd June, 2014

Major Advisor

DECLARATION

This is to declare that the whole of the research work submitted in this thesis for the partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** in **Agricultural Entomology** is the result of investigation done by the undersigned under the direct guidance and supervision of **Dr. K. G. Patel, Principal, College of Agriculture, Navsari Agricultural University, Bharuch** and that no part of the work has been submitted for any other degree so far.

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ABBREVIATIONS

AAU	:	Anand Agricultural University
<i>a.i.</i>		Active ingredient
AP		Andhra Pradesh
@		At the rate of
BACA		B. A. College of Agriculture
BNSS		Broadcasting of Nearly Sprouted seed
B.C.R.		Benefit Cost Ratio
°C		Degree Celsius
CD		Critical Difference
cm		Centimeter
Conc.		Concentration
Corr.		Corrected
C.V.		Co-efficient of variance
DAT		Days After Transplanting
DAS		Days After Spraying
DA		Days After
DB		Days Before
DBH		Days Before Harvesting
DH		Dead Heart
EC		Emulsifying Concentration
<i>et al.,</i>		et alii ; and co-workers
etc.		Etcetera; and rest, so on
Fig.		Figure
g		Gram
G		Granule
GAU		Gujarat Agricultural University
ha		Hectare
hrs		Hours
HS		Highly Susceptible
<i>i.e.</i>		That is
K	:	Potash
kg		Kilogram
m		Meter

m ²		Square Meter
Max.		Maximum
Min.		Minimum
ml		Milliliters
mm		Millimeter
MR	:	Moderately Resistant
MSRI		Modified System of Rice Intensification
MS		Moderately Susceptible
N		Nitrogen
NAU		Navsari Agricultural University
NS		Not Significant
%		Per cent
/		Per
P	:	Phosphorus
q		Quintal
RH		Relative Humidity
R		Resistant
Rs.		Rupees
RTP		Random Transplanting
2 nd		Second
S. E. m $\pm$		Standard Error of mean
Sig.		Significant
SP		Soluble Powder
Std. week		Standard Week
SRI	:	System of Rice Intensification
STP		Standard Transplanting
viz.		Namely
Wlk.		Walker
WEH		White Ear head

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the world's second most important cereal crop and known with different names in India as Dangar (Gujarat), Bhatt (Maharashtra), Chawal (U.P., Bihar), Voldu (A.P.), Dhan (W.B.), Chaul (Punjab), Shali (J & K), Nello (Tamil Nadu, Kerala). It is included in grass Family Poaceae, sub-family Oryzoidae. Asia is considered to be 'rice bowl' of world, where more than 90% of world's rice is produced and consumed. It is one of the oldest and second most intensively grown cereal crops next to wheat and ranks third in grain production.

At global level, it is a staple food crop of paramount importance to more than half of the population with regard to food value and is consumed by more than 60% of the world population. It provides 27% of dietary energy and 20% of dietary protein in the developing world. Besides, it contains easily digestible high quality starch, protein and vitamins of 'B' group. In addition to the food value, it acts as a valuable source of many byproducts. The crop is cultivated mostly in developing countries and is the primary source of income and employment for more than 100 million households in Asia and Africa (FAO, 2004).

Rice is life and princess among the cereals, the staple food of 65% of the total population in India. It constitutes about 52% of the total food grain production and 55% of total cereal production. Rice is grown under diverse growing conditions such as irrigated, rainfed lowland, rainfed upland and flood prone ecosystems. India is the largest rice growing country, while China is the largest producer of rice in the world.

Out of 722.22 MT production of rice in the world, Asian countries shared 90% (653.83 million tonnes) of world's rice production. While, India contributes 157.90 MT annual productions with 22% share of world's production and 24% of Asian countries rice production (FAO, 2011). In India, paddy is grown in 44.06 million ha constituting 34.4% of

the total cultivable area. About 70% of our farmers are cultivating paddy and the production is about 105.31 million tonnes and productivity being 2178 kg/ha. The productivity of rice has increased from 1984 kg per hectare in 2004-05 to 2393 kg per hectare in 2011-12. Gujarat occupies about 2% of area among rice growing states. It is grown on 8.36 lakh ha area, which comprises nearly 90% of *Kharif* and 10% of *Summer* season rice with a total production of 17.90 lakh tonnes and the productivity of 2141 kg/ha (Anonymous, 2012), but it is lower than the country's productivity.

South Gujarat is an important rice growing tract of the state belonging to Dang, Valsad, Navsari and Surat districts of State. These districts occupy maximum rice growing area of the state, where the crop is mainly grown in *Kharif* as well as in *Summer* season. The reason is quite obvious, as the irrigation is available round the year through Ukai-Kakrapar command area, which makes the thing favourable for rice cultivation even for double cropping in a year. Thus, two harvests in a year coupled with better market price has boosted the economical condition of rice growing farmers of Valsad, Navsari and Surat districts. However, the average productivity is quite low and it is yet to be fully exploited to its maximum extent.

In recent years, concern over food security is increasingly sensed, more in developing countries where rice production did not match the increasing population. With reduced land availability and increased demand for enhanced production, attention is turning towards intensification through higher fertilizer inputs and cropping. Attempts are being made in the state to increase the rice production by the high yielding varieties, adopting intensive cultivation including double cropping in a year. Such efforts in turn increased pest intensities and losses caused by pests remained an important constraint to achieve high rice yields (Waddington *et al.*, 2010). Similarly, lack of pest resistant varieties, poor water management and lack of suitable pest and disease

management strategies are the major constraints in rice production. Among these, the importance of reducing losses from pests.

Moreover, there has been a distinct change in the pattern and dimension of entomological problems on rice, in all the rice growing areas of the world. The South Gujarat region, where warm and humid climate exists throughout the year has also withstood this change. The pests which were so far considered to be of minor importance have arisen to prominence. This is partly due to the change in agronomic practices like crop spacing, creating microclimate favourable for pest build up, heavy doses of nitrogenous fertilizers with high yielding varieties rendering plants more susceptible to pests and monoculture of rice round the year without a proper crop rotation. However, the potential of productivity of high yielding varieties still not fully exploited because its production constrained by number of biotic and abiotic factors. Among the biotic stresses insect pests cause about 10-15% yield losses. The average yield losses in rice have been estimated to vary between 21-51 per cent (Krishnaiah and Varma, 2010).

In the way of these constraints, rice is facing the various pest problems starting from seedling to maturity stage. It is infested by more than 800 insect species (Grist and Lever, 1969). Out of which, 20 are of major economic significance. Together, they infest all parts of the plant at all growth stages and a few transmit virus disease (Pathak and Dhaliwal, 1981).

About 20 insect pests are of major economic significance, among these, yellow stem borer (*Scirpophaga incertulas* Walker), brown plant hopper (*Nilaparvata lugens* Stal.), green leaf hopper (*Nephotettix virescence* Distant and *Nephotettix nigropictus* Stal.), rice leaf folder (*Cnaphalocrocis medinalis* Guenee), Rice blue beetle (*Leptispa pygmaea* Baly), rice bug (*Leptocorisa acuta* Thunberg), paddy gall fly (*Orseolia oryzae* Wood-Mason), rice hispa (*Dicladispa armigera* Olivier), rice grasshoppers (*Hieroglyphus banian* Fabricius and *H. nigrorepletus* Bolivar), rice mealy bug (*Ripersia oryzae* Green) and Rice sheath mite

(*Steneotarsonemus spinki* Smiley) have been reported feeding on rice crop (Atwal and Dhaliwal, 2002).

A list of major, minor and sporadic pests attacking paddy crop in Gujarat is reported by Korat and Pathak (1997). With the introduction of changes in types of varieties being cultivated, practicing of different cultivation systems and concomitant alterations in rice based cropping systems, certain pests earlier regarded as minor pests but they have now assumed significance as pests of regional significance. Among these insect pests rice yellow stem borer, leaf folders, blue beetle, hopper complex and rice earhead bug, red sheath mites are important.

Depending upon the crop age, the incidence of insect pests and resultant yield losses vary. During the first 30 days after transplanting significant yield losses are reported due to stem borer to the extent of 10-15%. The crop growth period between 30-60 days after transplanting was most vulnerable resulting in major yield losses (20-68%) mainly due to stem borer, leaf folder and brown plant hopper. Beyond sixty days after transplanting, the crop damage is inflicted by stem borer and leaf folder causing 10 to 48% damage (Krishnaiah and Varma, 2010).

Yellow stem borer is one of the widely distributed, dominant and monophagous pest of paddy in the Indian subcontinent. It is damaging crop in nursery as well as in transplanted crop causing drying of central shoot known as 'dead heart' in young plants, boring at heading stage usually occurs at the peduncle node and 'white earhead' formed (Gupta *et al.* 2006).

Rice hoppers complex infest all stages of the rice crop and both nymphs and adults suck the sap from the base of the tillers, resulting in yellowing and drying of the plants. The symptoms spread as patches of infestation from a point outwards within the field. This condition is known as 'hopper burn'. Outbreaks of plant hoppers recently have caused serious concern and in the last decade plant hoppers have rapidly spread to newer non-traditional areas.

Rice earhead bug is also known as gundhi bug was reported as sporadic and minor pest of rice in South Gujarat. After 1996, the attack of this pest was found to be severe in Valsad, Dang, Surat and Navsari districts. This bug known to feed on the developing rice grains causing discolored, deformed, ill filled and empty/sterile grains and renders considerable qualitative and quantitative losses every year (Gupta *et al.*, 1993).

The incidence of leaf folder in Gujarat is more pronounced compared to other defoliating larvae. It has attained major pest status with the introduction of high yielding varieties and particularly in areas of high fertilizer use. It was recorded on paddy crop in the state for first time in 1964 (Patel *et al.*, 1964) and a sudden outbreak took place for first time in Gujarat during September-October, 1971 (Upadhyay *et al.*, 1975). For every unit increase in the leaf folder incidence at tillering, early earing and milky seed stage led to 2.81, 2.50 and 1.27% loss in yield during wet season, respectively (Pandya *et al.*, 1994).

Now a days, rice blue beetle occupying a major status at some hot spot area in South Gujarat. This pest in grub and adult stage feeding on the upper surface of rice leaves, causing longitudinal white streak of scraping along with of them. In severe incidence, the leaves folded longitudinally and dried up.

Among non insect pests, mites are now considered as a significant pest in rice. Phytophagous tarsonemid mites like *Steneotarsonemus spinki* (Smiley) known to damage parachymatous tissues of rice plant and reduce the amount of nutrients to the developing grains resulting in reduction of the grain weight and size. Feeding of these mites on reproductive parts of rice flowers results in grain sterility as well as these mites have also been reported as vector/carrier of pathogenic fungi.

For the management of rice insect pests, farmers are using indiscriminate doses of chemicals which have created number of problems *viz.*, insect resistance to insecticide, resurgence of pest,

problems of health hazards, environmental pollution, destruction of natural beneficial fauna of rice ecosystem, *etc.*

With this view, regular observations on incidence of pests in field not only found useful to determine the activity of insect pests in relation to several weather factors but also helps to study the population dynamics of the insects during particular period. To plan the different suitable control measures for the pest, knowledge of population dynamics is very much essential. It is also useful in development of forecasting model for pest. Use of population dynamic model for *S. incertulas* has been suggested as an aid to decision-making in borer management (Xia *et al.* 1991).

Much work has been done on the chemical control of rice pests in Gujarat (Korat, 1980, Purohit *et al.* 1988 a and b; Vavadia *et al.* 1996 and Korat *et al.* 2003^a), but very little attention has been given towards the use of system of rice intensification (SRI), modified system of rice intensification (MSRI), broadcasting of near sprouted seeds, standard transplanting and random process for the control of insect pests of rice under middle Gujarat condition.

The System of Rice Intensification (SRI), developed in Madagascar about 25 years ago, is gaining increasing credence and momentum as probably 5 lakh farmers. In more than 20 countries, now they are using this method to raise their rice production with reducing the use of external inputs and production costs. SRI crops are more resistance to crop loss due to less attack by insect-pests, diseases and fewer infested grains than the traditional practice (Anonymous, 2010^a). SRI has the potential for better nutrient-use efficiency and increased production. The cost of cultivation is also less. Quality seed, one of the important components, which is an issue in enhancing productivity, is also addressed as less quantities required.

Most of the hybrid paddy varieties have yet to reveal their full generic potential in terms of productivity. Perhaps the conducive factors leading to optimum productivity were missing. Of all insect control

methods, the planting of pest resistant varieties is the most effective because it leaves no insecticide residue in food or the environment and is constantly effective and generally compatible with other insect control measures. In absence of natural heritable resistance in rice varieties, resistance could be induced by alternate strategies to suppress certain pests. Besides these farmers are always worried about cost of production due to rise in inputs prices year by year. Host plant resistance is one of the reliable and sustainable components of Integrated Pest Management (IPM). There has been substantial progress in this area and number of paddy varieties/ lines have been developed and required to be screened out for their major insect pest susceptibility.

Adoption of integrated pest management is one of the best strategies to overcome these problems. Of late, there have been major changes in status of several pests under the influence of the environment and changing cultural practices. Hence, it was thought worthwhile to conduct an investigation on “Succession of rice pest complex and testing of different management modules against rice pest complex under South Gujarat condition” with the following objectives.

Objectives:

1. Seasonal incidence of rice pest complex in relation to different methods of sowing and its correlation with weather parameters
2. To know the varietal response against rice pest complex
3. To know the effectiveness of insecticides against rice yellow stem borer
4. To evaluate different modules for management of rice pest complex

CHAPTER II

REVIEW OF LITERATURE

Rice is a staple food for a large part of the world's human population and it the second-most consumed cereal grain. Being a staple food crop, rice is facing various pest problems starting from seedling stage to maturity. With the introduction of high yielding and fertilizers responsive improved cultivars in intensive multiple cropping system of farming has lead to drastic change in rice ecosystem and insect pests become the major production constraint. For the management of rice insect pests, farmers are using indiscriminate doses of chemicals that have created number of problems *viz.*, insect resistance to insecticide, resurgence of pest, problems of health hazards, environmental pollution, destruction of natural beneficial fauna of rice ecosystem, *etc.*

Adoption of integrated pest management is one of the best strategies to overcome these problems. Of late, there have been major changes in status of several pests under the influence of the environment and changing cultural practices. Hence, it was thought worthwhile to conduct an investigation on “Succession of rice pest complex and testing of different management modules against rice pest complex under South Gujarat condition”

The studies have been made by various scientists on different aspects of rice pest complex are reviewed as under:

2.1 Seasonal incidence of rice pest complex in relation to different methods of planting and its correlation with weather parameters

2.1.1 Conventional method

2.1.1.1 Rice yellow stem borer (*Scirpophaga incertulas* Wlk.):

Mohan and Janarthanan (1985) conducted a study to see the effect of light trap on settlement of yellow stem borer near the light trap

zone revealed a positive correlation ($r = 0.79$) between the moth attracted to the trap and those settled around the trap zone. This results in significantly higher incidence of the pest with proximity to the trap.

Nandihalli *et al.* (1990) monitored the population fluctuations of *S. incertulas* at Raichur (Karnataka) during 1987- 89 and found two peak periods of adult's activity in both the years, the first in October to December and the second in March to May. They also reported that the pest was inactive during June to September in both the years.

Ramakrishnan and Venugopal (1991) correlate the dead heart/ whitehead incidence due to stem borer infestation with weekly mean weather parameters and showed that fitted multiple regression equations explained approximately 50% variation in dead heart/ whitehead damage due to weather, but none of the factors contributed significantly to stem borer infestation.

Sarkar and Gayen (1992) observed two major peaks of *S. incetulas* adults, one in October to November and another during February in West Bengal. They also reported that peak activity of the pest depended on the availability of rice crop in the fields and the female population was always lower than that of male population.

Bhatnagar and Saxena (1999) studied the effect of climate on the population buildup of yellow stem borer by using light traps over four years (1994-97) at Jagdalpur and observed that the relatively higher number of moths were trapped during October, with the highest activity in the final week. Yellow stem borer numbers showed a significant negative correlation with minimum temperature, evening relative humidity and rainfall.

In the field study of Tripathy *et al.* (1999), yellow stem borer produced two broods with first peak during the last week of September and the second peak during the second week of November, which coincided with the dough stage of rice.

From Rajendranagar (A.P.,) Kumar and Sudhakar (2001) reported that the peak activity of yellow stem borer was observed in second fortnight of October during *Kharif* and second fortnight during *Rabi*.

Rai *et al.* (2002) conducted a long term (1975-1995) study at Pusa (Bihar) and revealed that the peak occurrence of yellow stem borer was observed during first fortnight of October. This period coincided with range of favourable environmental factors during *Kharif* season.

Padhi and Saha (2004) reported that maximum temperature, rainfall, relative humidity and wind velocity were negatively correlated, while minimum temperature, evaporation rate and sunshine hours were positively correlated to the yellow stem borer moth population.

Misra *et al.* (2005) found the minimum number of dead hearts (2.8%) per five hills during 11th standard week of March and 6.2% peak in cultivar Gautam in 20th standard week of May 2002. The relative humidity and rainfall had significant positive correlation coefficient in respect to white ear head.

Kharat (2006) revealed that the incidence of stem borer increased from 32nd standard week and it started declining from 42nd standard week. Furthermore, the fluctuations in the per cent dead hearts from 34th to 44th standard week were due to the need based application of insecticides. The correlation matrix indicated that correlation between incidence of stem borer and rainfall, maximum temperature and number of rainy days exhibited non-significant negative correlation while, incidence of stem borer exhibited non-significant positive correlation with minimum temperature, average temperature, morning, evening and average humidity and sunshine hours and wind velocity.

Adiroubane and Raja (2007) observed the high incidence of rice yellow stem borer during months of March (Navarai – *Rabi*, 2005), August- September (Kuruvai – *Kharif*, 2006) and October-November (Samba – *Rabi*, 2006).

Hugar and Venkatesh (2009) studied the influence of weather factors on the infestation of *S. incertulas* in aerobic rice and the results revealed that yellow stem borer infestation attained its peak activity when the crop was 60 days old during *Kharif* 2005, while in *Rabi* 2006, the peak activity was noticed at 75 days after sowing. Regression equations between the infestation of stem borer and weather parameters showed a significant negative correlation with minimum temperature and afternoon relative humidity, but showed non-significant and negative correlation with maximum temperature, morning relative humidity and rainfall and had significant positive correlation with sunshine hours in *Kharif*. While in *Rabi* season, per cent dead heart or white ear head showed significant positive correlation with morning and afternoon relative humidity and non-significant positive correlation with the mean sunshine hour per day.

According to Saikia (2009), stem borer's moth population decreased from the month of May to mid August (20-60 moths/week) and it was further increased (238-515 moths/week) from mid August to mid October.

The results of Kumar *et al.* (2011^a) on population dynamics of yellow stem borer, *S. incertulas* revealed that the average maximum moth catch 82.44 per trap was observed in the month of October, while minimum only 0.22 moth per trap about negative were observed in the month of December. The moth catch positively influenced with increase in temperature, relative humidity and rainfall during every year, while wind speed and sunshine causes negative effect on moth catch.

The activity of yellow stem borer, *S. incertulas* was observed from 3rd week of August to 2nd week of November showing peak level during 2nd week of September. The peak activity of *S. incertulas* was observed from 4th week of August to 2nd week of September at vegetative stage and 3rd week of October to 2nd week of November at reproductive stage. The maximum temperature as well as bright sunshine hrs had negative correlation with yellow stem borer incidence at pre-harvest, while

minimum temperature, morning relative humidity, evening relative humidity and rainfall had positive correlation with the yellow stem borer (Sankpal, 2011).

In the experiment of Gole (2012) the incidence of *S. incertulas* started during second week of August (32nd SMW). The periodical data on dead hearts due to *S. incertulas* were recorded starting from the infestation up to the harvest of the crop.

The seasonal incidence of rice yellow stem borer was studied by Justin and Preetha (2013) at Thirupathisaram, TNAU, Kanyakumari district from 2008 to 2011 and the results revealed that the infestation was found during August-September and December-February, reaching the peak in January – February and without any infestation in other months. The studies on correlation with weather parameters showed a significant positive correlation with relative humidity and negative correlation with minimum temperature and rainfall.

2.1.1.2 Green leaf hopper (*Nephotettix virescens* Distal):

Kharat (2006) presented that correlation between green leaf hopper population and maximum temperature, morning relative humidity and sunshine hours were positively non-significant. The rainfall, evening relative humidity, average relative humidity, wind velocity and rainy days were negative non-significantly correlated with pest population.

Shamim *et al.* (2009) analyzed the effect of weather parameters on population dynamics of green leaf hopper in paddy of Middle Gujarat region. The results indicated that the bright sunshine hours had a positive significant correlation with the population dynamics of green leafhopper, while maximum temperature, minimum temperature, rainfall and relative humidity showed non-significant effect on population build-up of green leaf hopper. Green leaf hopper attained peak population during 43rd SMW.

2.1.1.3 Brown plant hopper (*Nilaparvata lugens* Stal.):

Alam and Rezual karim (1976) reported the brown plant hopper outbreak and observed severe hopper burn field at Bangladesh Rice Research Institute, Dhaka both in *summer* and *kharif* paddy seasons with about 100 to 200 hoppers/hill.

Das and Thomas (1977) evaluated the effect of water level in rice fields on the population build-up of the brown plant hopper, *N. lugens* and observed large population peaks in the water level of immersing stem and leaf sheath (25%) which was more than the damage caused at normal water level in field (11%).

Nair and Nair (1977) studied the population fluctuation of rice brown plant hopper at Kuttanadu, Kerala where variety Jaya cultivated widely and recorded regular occurrence of hopper burn twice in a year with heavy yield and quality losses.

Chatterjee (1978) noted the occurrence of rice brown plant hopper at Khanakul, West Bengal and found epidemics of hoppers with severe hopper burn symptoms resulted in low to no yield potential.

Narrayanasamy *et al.* (1979) conducted the biological studies on the population dynamics of rice brown plant hopper and found positive correlation with higher humidity and negative correlation with rainfall and temperature.

An experiment was carried out by Nair *et al.* (1980) to study the influence of climatic factors on population of the brown plant hopper in Kuttanad, Kerala, wherein they found that *N. lugens* was present in the field throughout the year with its peak population in January-March and lower population in August-September. The correlation studies showed that the hopper population was significantly influenced by climatic factors, especially rainfall in association with high relative humidity.

Sarma and Channabasavanna (1980) reported the population growth of brown plant hopper with release of five pairs of adults per

plant and observed cent per cent hopper burn and 30 to 100% yield loss accordingly.

In the field studies of Khaire and Dumbre (1984) revealed that the adults of brown plant hopper were first appeared in mid September and reached to peak numbers in November coinciding with flowering, dough and grain formation stages in the Konkan region of Maharashtra.

Sogawa *et al.* (1986) recorded the population dynamics of the brown plant hopper in irrigated lowland areas of rice and found that nymph population was initiated at 5-6 weeks after transplanting and reached to its peak at 9-11 weeks after transplanting, while brachyopterous females emerged at 6-8 weeks after transplanting.

According to Jeyarani (2004), the seasonal incidence of brown plant hopper caused maximum damage in September, October and January. He also observed negative correlation with excessive rainfall and showed non-significant relationship with other weather parameters.

Kharat (2006) studied the correlation coefficient for population of brown plant hopper and weather parameters and revealed that positive significant correlation existed between pest population and maximum temperature and sunshine hours. The evening humidity average humidity, wind velocity and rainy days exhibited negatively significantly correlation with pest population. The pest population was negatively non significant with rainfall, minimum temperature and morning humidity while it was positively non-significant average temperature.

In the findings of Desai (2008) found that the population build up of rice brown plant hopper in the field was initiated in *Kharif* 2007 from 37th SMW and reached to its peak level (1.19 nymph/hill, 0.89 adult/hill and 2.20% damaged hills) during 42nd SMW. In *Kharif* 2007, the damage of brown plant hopper had significant positive correlation with maximum temperature ($r = 0.815$), whereas significant negative correlation with minimum temperature ($r = -0.850$), morning relative humidity ($r = -0.727$), evening relative humidity ($r = -0.864$), average

relative humidity ($r = -0.851$), wind velocity ($r = -0.548$) and rainy days ($r = -0.681$), while rest of the weather parameters had non-significant either positive or negative correlation. The nymphal population of rice brown plant hopper had significant positive correlation with maximum temperature ($r = 0.845$), whereas minimum temperature ($r = -0.858$), morning relative humidity ($r = -0.785$), evening relative humidity ($r = -0.892$), average relative humidity ($r = -0.887$) and rainy days ($r = -0.698$) had significant negative correlation, while rest of the weather parameters had non-significant either positive or negative correlation.

Chander and Palta (2010) studied the effect of weather factors on outbreak of brown planthopper, *N. lugens* in rice and stated that temperature cloudy weather and well distributed intermittent rainfall and relatively calm conditions leading to high humidity during June-August in 2008 were quite favourable for the BPH growth and multiplication.

Yadav and Chander (2010) developed multiple linear pest-weather regression model between weather factors and logarithmically transformed BPH light trap catches observed during *kharif* 2000 to 2007 at Maruten, Andhra Pradesh. The pest-weather model involving three weather parameters *viz.*, maximum temperature, minimum temperature and relative humidity was found to be the best fit as all the three weather factors showed significant influence on BPH light trap catches with the coefficient of determination (R^2) being 0.674.

2.1.1.4 Rice earhead bug (*Leptocorisa acuta* Stal.):

Singh and Chandra (1967) reported the population dynamics of *L. varicornis* in rice and found the peak population of bugs was either in late September or early October and were also observed that the population peaks increased as the differences in rainfall decreased.

Pathak (1968) recorded the maximum population of the bugs during September and population declined later on from end of October.

Garg and Sethi (1980) found optimum temperature ($26.63 \pm 1.81^{\circ}\text{C}$) and adequate sunshine hours (9.02 ± 0.18 hr.) were to be the most conducive climatic factors favouring the higher population build up of *L. acuta* in rice fields.

According to the results of Butani and Jotwani (1976), Grist (1981) and Saroja and Raju (1985) the earhead bugs remained in the field till the grain hardening take place and the successive generation migrated from early maturing varieties to late maturing varieties.

Rai *et al.* (1990) employed 'Mitsuo Yosimeki' light trap for quantitative estimation of rice bugs, *L. varicornis* in two different sites and noted two major peaks at 37th SMW (2nd week of September) and 40th SMW (1st week of October) with one minor peak at the 43rd SMW (4th week of October) at both sites.

Shanmugan and Sivasubramanian (1996) found that the earhead bugs (*L. acuta*) remained active throughout the year without a distinct diapause in places where temperature was optimum.

Bhatnagar and Saxena (1999) showed the influence of weather factor on the population build-up of *L. acuta* through light trap collection and observed that *L. acuta* had significant negative correlation with low sunshine and maximum temperature.

Deore (2002) studied the fluctuation of nymphal and adult population of earhead bug (*L. acuta*) on rice. The data showed that the population of earhead bug was observed from third week of September to second week of November. The population ranged from 0.67 to 14.00 bugs per twenty hills. The population was at its peak level (14.00 bugs/twenty hills) in first week of November, while the least population (0.67 bugs/twenty hills) was observed in third week of September. The correlation matrices indicated that earhead bug (*L. acuta*) population and weather parameters were non-significant indicating that there was no correlation between them. There existed a significant positive correlation between bug population and maximum temperature only.

Samui *et al.* (2004) recorded the peak infestation of rice earhead bug in the 46th SMW. The earhead bug population at 46th SMW was influenced by maximum temperature of more than 31.9°C, morning relative humidity more than 93.9% of 43rd SMW, more than 5.9 bright sunshine hrs of 44th SMW, afternoon relative humidity less than 66.4% of 44th SMW and weekly total rainfall less than 40.9 mm of 42th SMW.

Pushpakumari and Tiwari (2005) noted the population of *L. acuta* in the 1st week of September just before flowering of the crop. The mean number per hill varied from 0.01 to 0.36 and the highest number was recorded in 2nd week of October, which was at the milky stage of the crop.

Takeuchi *et al.* (2005) found that over wintered adults of *L. chinensis* appeared in grass fields from late June to early July and their population fluctuation until October end.

The record of Ghule (2006) on the population of earhead bug was observed in the range from 1.15 to 12.05 bugs per five net sweeps from second week of September (37th STW) to first week of November (45th STW). The population reached its peak (12.05 bugs/five net sweep) in 4th week of October (43rd STW) during milky stage of crop while the least population (1.15 bugs/per five net sweep) was observed in second week of September (37th STW). The correlation coefficient results indicated that there was significant positive correlation of earhead bug population existed with maximum temperature and sunshine hours whereas, significant negative correlation was existed between bug population and weather parameters viz., evening relative humidity, rainy days and wind velocity. This indicated that increase in these weather parameters have a negative impact on population build up of *L. acuta*.

Kharat (2006) indicated that gundhy bug population was negative significantly correlated with minimum temperature, morning relative humidity, Evening relative humidity, wind velocity and rainy days. The correlation between pest population and maximum temperature and

sunshine hour was positively significant while it was negative non-significantly correlated with rainfall.

2.1.1.5 Rice leaf folder (*Cnaphalocrocis medinalis* Guenee)

There was continuous cropping of rice in Tami Nadu, where *C. medinalis* occurred throughout the year, generally reaching peak numbers during October-November and April (Velusamy and Subramaniam, 1974).

Balasubramanian *et al.* (1982) tested the influence of weather factors on damage potential of leaf folder in rice. They recorded the leaf folder damage in the late vegetative phase with main infestation of 4.35 per cent for the entire cropping period in February transplanted crop and 10.12 per cent in August transplanted crop at Coimbatore. Similarly, corresponding decrease in the damage by the leaf folder was observed from 13.00 per cent in September transplanted crop to 5.33 per cent in April transplanted crop at Bhavanisagar.

Ram (1986) observed the population of *C. medinalis* peaked in October, when about two-thirds of the leaves in infested fields were folded in Haryana.

During wet season, an outbreak of *C. medinalis* was observed on paddy in several regions of Haryana. Infestation began in the first week of August and lasted until the first week of October. Infestation peaked during second week of September when crop was at the booting to panicle emergence stage (Kushwaha, 1988).

A study revealed that the leaf roller in *kharif* as well as *summer* season showed non-significant correlation with all the weather parameters. However, it showed negative non significant correlation with temperature and sunshine hours (Anonymous, 1996^a).

In the population study of Islam *et al.* (1996) found larval in density (0-2.89/m²) and leaf damage (0-3.34%) due to rice leaf folder in six successive seasons in Gazipur.

Kraker *et al.* (1999) from Philippines reported that population dynamics of leaf folder were characterized by an egg peak at maximum tillering and a broad larval peak around booting stage. Peak densities ranged from 0.2 to 2.0 larvae/hill.

Kaul and Singh (1999) found the peak activity of adults of *C. medinalis* during the fourth week of August, whereas that of larvae occurred during the second week of September. They observed a significant positive correlation of *C. medinalis* population with rainfall and rainy days.

The leaf folder infestation at grain filling stage was more detrimental which was in accordance with the findings made by Saikia and Parameswaran (1999).

In the results of Manisegaram and Letchoumanane (2001) found that a unit increase in the minimum temperature caused an increase in the population of rice leaf folder adults, while there was negative correlation between RLF population and relative humidity.

Mishra *et al.* (2001) observed maximum leaf folder damage during maximum tillering stage of the crop.

While, Patnaik (2001) pointed out that a fall in the temperature during the last week of September and first week of October recorded increased infestation of leaf folder in rice.

Subhas Chander (2001) reported that the damage caused by *C. medinalis* peaked towards the late growth stage of rice crop in New Delhi.

Alvi *et al.* (2003) noted the peak activity of *C. medinalis* in second fortnight of September.

The reports of Kumar *et al.* (2003) illustrated that the peak activity of leaf folder occurred in the first fortnight of August during the *Kharif* season and in February during the *rabi* season. There was a significantly negative correlation of leaf folder with morning relative humidity.

Subhash *et al.* (2004) found that temperatures ranging from 26.5 to 28.5°C were associated with lower pest incidence, while temperatures ranging from 28.2 to 30.5°C were associated with moderate pest incidence.

Kharat (2006) revealed that leaf folder incidence was started increasing from 32nd standard week and started declining from 42nd standard week. The incidence was found highest in 41st standard week. Furthermore, the fluctuations in the per cent leaves damaged by leaf folder in 34th to 44th standard week were due to need based application of insecticides. The results indicated that leaf folder incidence exhibited non-significant positive correlation with maximum temp., minimum temp, average humidity and sunshine hours. The correlation between leaf folder and rainfall, Evening humidity, wind velocity and rainy days were negatively non-significant.

Patel (2006) recorded the larval population (0.50 larva/plant) and per cent damaged leaves (0.55) of rice leaf roller initiated from 36th standard week and reached to it's peak level (3.12 larvae/plant and 3.20 per cent damaged leaves) during 43rd standard week. Then after, larval population and per cent damaged leaves was gradually declined and reached to a zero level at the maturity of crop. The leaf roller damage exhibited significant positive correlation with maximum temperature ($r=0.582$) and sunshine hours ($r=0.507$), while non-significance negative correlation was observed with minimum temperature ($r=-0.334$), average temperature ($r=-0.021$), morning relative humidity ($r=-0.007$), evening relative humidity ($r=-0.353$), average relative humidity ($r=-0.253$), wind velocity ($r=-0.428$), rainfall ($r=-0.244$) and rainy days ($r=-0.407$).

Sankpal (2011) showed that the higher incidence of *C. medinalis* was observed from 3rd week of September to 3rd week of October. The maximum temperature and bright sunshine hours had significant positive relationship with *C. medinalis* population. Minimum temperature, morning relative humidity, evening relative humidity and rainfall had negative association with the population of *C. medinalis*.

In the experiment of Boopathi (2012) showed that leaf folder, *C. medinalis* was initiated on last week of August and reach peak population of during third week of September (0.33), which decline in preceding weeks. Leaf folder established negative significant correlation with maximum temperature ($r = -0.707$).

Gole (2012) studied the incidence of rice leaf folder, *C. medinalis* and showed that the infestation was started during second week of August (32ndSMW). The periodical data on leaf damage due to *C. medinalis* were observed starting from the infestation up to the harvest of the crop. The data on per cent leaf damage pooled over periods revealed that all planting methods recorded varied per cent leaf damage (2.39 to 5.73) from each other. Chronologically, planting methods in comparison to each other based on per cent leaf damage due to *C. medinalis* in bracket was: STP (2.39) > RTP (2.56) > SRI (3.69) > MSRI (4.76) > BNSS (5.73). Same trend was observed as STP found significantly superior than rest of the treatments and recorded lowest (2.39) per cent dead hearts which was at par with RTP and also recorded the 2.56 per cent dead hearts. SRI, MSRI and BNSS were differed statistically from each other and registered 3.69, 4.76 and 5.73 per cent dead hearts, respectively.

2.1.1.6 Rice blue beetle (*Leptispa pygmaea* Baly.):

Patel (1977) noted the highest pest population of rice blue beetle in the month of August and September *i.e.* 11.87 and 10.36 insects/plant in 1975 and 8.25 and 8.35 insects/plant, respectively in 1976 during *kharif* season.

Dalvi *et al.* (1985) reported that the blue beetle incidence started in the field during the second fortnight of July. They also pointed out that the month of August and September were generally more congenial for rapid build-up of the pest.

The damage of rice blue beetle was observed during 35th to 38th standard week in *Kharif* 2001 at Navsari (Anonymous, 2002^b).

The average infestation of rice blue beetle was 0.10 per cent during in *kharif* 2002 and average number of beetles per plant *summer* 2002 was 0.60 per cent (Anonymous, 2003^{a & b}).

Rice blue beetle was observed during the 39th to 41st standard week with the average of 0.23 per plant during *summer*. Similarly, pest caused 0.28 per cent infestation during the 33rd to 36th standard week in *kharif* at Navsari (Anonymous, 2006^{a & b}).

Kharat (2006) revealed that the incidence of blue beetle increased from 32nd standard week in all treatments including control and started declining from 42nd standard week. The results indicated that blue beetle incidence and minimum temperature, maximum temperature, average temperature, morning relative humidity, average humidity and sunshine hours exhibited positive non-significant correlation. The correlation between Blue beetle incidence and rainfall, evening relative humidity, wind velocity and rainy days was negatively non-significant.

The incidence of rice blue beetle was 0.16 per plant during in 39th to 41st standard week of summer and caused 0.17 per cent infestation during 33rd to 36th standard week of *Kharif* at NARP, Navsari (Anonymous, 2007^{a & b}).

The data of Patel (2008) showed that population of rice blue beetle (1.08 beetle/plant) and per cent damaged leaves (1.03%) was initiated from 31st standard week and reached to its peak level (3.01 beetle/plant and 3.93 per cent damaged leaves) during 34th standard week of *kharif* 2007 at Navsari. Then after, beetle population (0.94 beetle/plant) and per cent damaged leaves (1.07%) was gradually declined and reached to a zero level at maturity of crop. The correlation results indicated that evening relative humidity ($r = 0.546$) and average relative humidity ($r = 0.539$) had significant positive correlation with the adult population of blue beetle, while maximum temperature ($r = -0.566$) had significant negative correlation with the adult population of blue beetle. Minimum temperature ($r = 0.455$), morning relative humidity ($r = 0.464$), wind velocity ($r = 0.323$), rainfall ($r = 0.220$) and rainy days ($r = 0.398$) had non-

significant positive correlation, while average temperature ($r = -0.195$), sunshine hours ($r = -0.447$) and evaporation ($r = -0.075$) had non-significant negative correlation with the adult population of blue beetle.

2.1.1.7 Rice sheath mite (*Steneotarsonemus spinki* Smiley):

Bandhaniya (2005) reported the peak incidence of mite on rice crop was started from 36th SMW (September first week) and there was a gradual increase in population and reach its peak during 43rd SMW (October last week) during both the seasons during *kharif* 2002 and 2003. Mite population was ranged from 0.95 to 44.92 and 1.06 to 71.65 per leaf sheath during *Kharif* 2002 and *Kharif* 2003, respectively.

2.1.2 SRI method

Adoption of System of Rice Intensification (SRI) practices in South India for the reduction in pest problem mainly plant hoppers, gall midge, whorl maggot and stem borers and biodiversity indices revealed that SRI principles *viz.* intermittent irrigation and weeding by cono weeder have negative impact on the diversity of aquatic arthropods in rice ecosystem (Anonymous, 2002^a).

Kumar *et al.* (2007) carried out a field experiment at Ramachandrapuram on three methods of crop husbandry (SRI, Eco-SRI and Conventional) against insect pests of rice and found that maximum white earheads due to yellow stem borer were observed in SRI (12.5 %) followed by conventional (8.9%) and ECO-SRI (6.2%).

Influence of SRI on incidence of insect pests of rice studied at Rajendranagar revealed that yellow stem borer damage at vegetative stage was low in variety Shanti grown under SRI (7.0%) as compared to Standard Transplanting (11.4%), while at reproductive stage, the damage of white earheads was high in SRI (28.3%) than conventional method (21.2%) (Anonymous, 2009).

Studies on rice pest scenario under two methods of rice cultivation *viz.*, System of Rice Intensification (SRI) and Normal System of Cultivation (NSC) carried out at Palakkad (Kerala) during the second

crop season of 2009-2010 revealed that the incidence of yellow stem borer was significantly reduced by 59.65 and 56.22% dead hearts and 26.37 and 40.22% white earheads in Uma and CORH 3, respectively in SRI (Anonymous, 2010^b). This cultivation method also significantly reduced the damage of whorl maggot by 27.91 and 44.85% in the two varieties and recorded higher yield of 6180 and 7040 kg/ha with a higher cost benefit ratio of 1: 2.4 and 1: 2.7, respectively in above both hybrid rice.

Gole (2012) showed that all planting methods recorded varied per cent dead hearts from each other. The lowest per cent dead hearts due to *S. incertulas* was found in SRI (2.51%), followed by Modified SRI (MSRI) (2.73%), Standard Transplanting Method (STP) (4.47%), Broadcasting of Near Sprouted Seeds (BNSS) (6.14%) and Random method of Transplanting (RTP) (7.54%). SRI found significantly superior than rest of the treatments and recorded lowest 2.51% dead hearts, which was at par with MSRI recording 2.73% dead hearts. White earhead damage due to *S. incertulas* was recorded 15 days before harvesting. The lowest per cent white earheads due to *S. incertulas* was found in SRI (1.22%), Modified SRI (MSRI) (1.23%), Standard Transplanting Method (STP) (2.93%), Broadcasting of Near Sprouted Seeds (BNSS) (3.97%), Random method of Transplanting (RTP) (5.38%). SRI and MSRI planting methods were at par with each other and found to be effective as recorded the lowest 1.22 and 1.23% dead hearts.

2.1.3 Natural Enemies:

Chandramohan and Chelliah (1990) recorded *Tetrastichus schoenobii* as egg parasitoids on yellow stem borer, *S. incertulas* predominantly caused parasitism to the extent of 46.63 per cent in February. The activity of *T. schoenobii* was negatively influenced by maximum temperature and wind velocity. Among the larval parasitoids, *Apanteles schoenobii* registered 10.26 per cent parasitism during January-February.

Barrion and Listinger (1995) also reported 342 species of spiders belonging to 131 genera under 26 families in rice field of South and South-east Asia. They found that the species richness and species diversity of spiders increased with age of rice crop.

Ganeshkumar and Velusamy (1996) surveyed the population of spiders in rice fields of Tamil Nadu and reported 21 species under 7 families.

Islam *et al.* (1996) recorded about 15 parasitoids species were attacked the rice leaf folder and average parasitism in 13 crop seasons was 34.6% (6-45%), which seemed to play an important role in population suppression.

Anbalagan and Narayanasamy (1999) reported 21 species of spiders under 16 genera in 10 families from rice fields of Tamil Nadu. Among them, *Lycosa pseudoannulata*, *Oxyopes javanus*, *Pardosa sumatrana*, *Tetragnatha mandibulata*, *Tetragnatha maxillosa* and *Tetragnatha javana* were the most abundant species of spiders.

Manju *et al.* (2002) studied the egg parasitism in yellow stem borer, *S. incertulas* on rice cv. ADT 39 in Tamil Nadu in both wet and dry seasons in 1999-2000. The investigation showed that the egg masses were more numerous at panicle initiation stage than at tillering stage and flowering stages and therefore the parasitism was higher at panicle initiation stage (45%) than at flowering (29.86%) and tillering (21.23%) stage. The parasitism was due to both *Telenomus dignus* and *Tetrastichus schoenobii*. *T. dignus* occurred all the year, while the occurrence of *T. schoenobii* was seasonal and parasitization was significantly higher due to the former (71.27%) than due to the later (28.72%).

Khan and Misra (2003) studied the abundance of spider fauna in upland and lowland rice ecosystem at Varanasi, Uttar Pradesh during the *kharif* season and reported 14 species of predacious spiders belonging to 10 genera under 7 families.

Manthirajan and Regupathy (2003) evaluated the prey preference of three major spiders of rice viz., *Lycosa pseudoannulata*, *Oxyopes javanus* and *Tetragnatha javana* against sucking pests. The study showed that all these three species showed greater preference to *N. lugens* and *Sogatella furcifera* and *N. virescens*. *L. pseudoannulata* was an efficient predator followed by *T. javana* and *O. javanus* and female was more efficient than the male.

Vijaykumar and Patil (2004) surveyed the population of spiders in rice fields of Karnataka and reported 17 species of spiders belonging to 14 genera and 8 families. They found that the salticidae and araneidae were common.

Misra *et al.* (2005) observed the incidence of yellow stem borer and spider population in different cultivars and they found that the minimum spiders 4.6 m⁻² was recorded in the 11th standard week with two peaks 10.6 and 10.2 in 16th and 19th standard week, respectively. The impact of weather parameters in general, were found positive except negative influence of rainfall on spider population.

Kharat (2006) revealed that the population of spiders increased from 32nd standard week, it was maximum in 40th standard week and started declining from 41st standard week in all the treatments. The spider population was positive non-significantly correlated with maximum temperature, minimum temperature, average temperature, morning relative humidity and sunshine hours while, rainfall, evening relative humidity, average relative humidity, and wind velocity showed negatively non-significant correlation with spider population. The spider population showed negatively significant correlation with rainy days.

In the findings of Desai (2008) found that the population of spider (0.35/hill) initiated from 29th SMW and reached to its peak level (2.22/hill) during 34th standard week in *kharif* 2007.

Kumar *et al.* (2008) studied the biodiversity of natural enemies in paddy ecosystem and their seasonal dominance and they recorded the most common and dominant predators were spiders, coccinellids,

staphylinids, mirids, damsel flies and dragon flies. The maximum population (number per 10 hills) of spiders (3.00), coccinellids (2.50), staphylinids (2.50), mirids (2.25), damsel flies (0.75) and dragon flies [Odonata] (0.75) was found in the 2nd week of August, followed by the 3rd week, while the lowest population of spiders (1.25), coccinellids (1.50), staphylinids (1.00), mirids (1.25), damsel flies (0.25) and dragon flies (0.50) was observed in the 3rd week of October, followed by the 2nd week of the same month. Similarly, the egg parasitoids had greater impact on the suppression of rice stem borer (*S. incertulas*) and the most important egg parasitoids observed were *Telenomus* sp. and *Tetrastichus schoenobii* parasitizing up to 78.4 and 95.8 of October (95.8%), followed by the 3rd week (90.9%), while the lowest egg parasitization was found in the 1st week of August (6.4%), followed by the 2nd week.

Patel (2008) showed that the population of spider (0.25/plant) was initiated from 29th standard week and reached to its peak level (2.12/plant) during 34th standard week of *kharif* 2007 at Navsari. Then after, the spider population declined and reached to 0.10/plant at the time of harvest. The correlation results indicated that minimum temperature ($r = 0.470$), morning relative humidity ($r = 0.364$), evening relative humidity ($r = 0.476$), average relative humidity ($r = 0.461$), wind velocity ($r = 0.366$), rainfall ($r = 0.101$), rainy days ($r = 0.325$) and evaporation ($r = 0.042$) had non-significant positive correlation with the spider population. While maximum temperature ($r = -0.475$), average temperature ($r = -0.031$), sunshine hours ($r = -0.395$) had non-significant negative correlation with the spider population.

Saikia and Baruah (2008) conducted survey to study the relative abundance of rice field spiders among rainfed dryland (Ahu), rainfed wetland (Sali) and irrigated wetland (Boro) environments in Northern Assam. They recorded 16 species belonging to 14 genera under 8 families comprising the spider fauna in rice ecosystems. *Tetragnata mandibulata* (26%) was maximum followed by *Harmochris braciatus* (18.4%) in Sali rice whereas, *Oxyopes* sp. was predominant in both Boro (51.1%) and Ahu (30.0%) rice ecosystems.

The predatory spider population study was made by Sankpal (2011) and the results exhibited significantly positive correlation with maximum temperature and sunshine hours and significant negative correlation with evening relative humidity. However, minimum temperature, morning relative humidity and rainfall exhibited negative correlation with the population of predatory spiders. The predatory spider population exhibited positive correlation with the incidence of all the three insect pests *viz.*, yellow stem borer, leaf folder and white backed plant hopper. Thus, population of predatory spiders was found to be increased with increasing the incidence of yellow stem borer, white backed plant hopper and leaf folder during the crop period.

Abundance and diversity of predator species during different growth stages of rice crop in untreated field was analysed by Rajna and Chander (2013) through Simpson index, Shannon-Wiener index and Berger-Parker index. They observed 15 species of predator on rice pests during the crop season included 9 spider species, 1 species each of mired bug and rove beetle, and two carabid and coccinellids species each. Spiders were dominant during early crop stages, while mired bug dominated during post-flowering period. Spider and mired bug populations were positively correlated with plant hopper population and these exhibited a sort of population regulatory behavior.

The seventeen species of parasitoids found upon six insect pests were collected by Dhanapati Devi and Varatharajan (2013) from the rice growing areas of Valley districts of Manipur. These parasitoids belonged to family Braconidae, Ichenumonidae, Chalcididae, Eulophidae and Tachinidae, and were active from June to November with 3-45% parasitism.

2.2. Varietal response against rice pest complex:

2.2.1 Rice yellow stem borer (*S. incertulas*):

Balasubramanian *et al.* (1986) screened seventeen entries of rice for their resistance to stem borer in Tamil Nadu and reported that DPI 1091/1-3, Sornavazhai, TKM 9 and W1263 were found moderately

resistant to stem borer damage up to 30 days after transplanting, while Co18, Co21, SB13 and SB19 were found moderately resistant to white earhead damage. They further reported that two entries *viz*; IR50 and Paiyur 1 were found moderately resistant to stem borer at both the stages.

According to Kulkarni *et al.* (1987), among the 24 rice genotypes tested for their resistance to yellow stem borer, the genotypes *viz*; ARC 5500, ARC 6588, Co 18, RYT 2908, W 1263, ASD7, T7, RP 219-115-2, ARC 6215 and Manoharshali were found resistant (0 - 5 % DH), while RP 2199-62-2 showed moderately resistant (5.1 - 10% DH).

Rao and Padhi (1988) conducted 11 varietal screening trials in *kharif* and *rabi* seasons at Cuttack, Orissa under outbreak conditions involving 352 entries and 5 varieties. Among the screened cultures, CR-260-30, W 11253, W 1263, IR 9828-23-1, IR-15723-45-3-22-2 and Mahsuri proved consistently resistant to yellow stem borer.

Tiwary *et al.* (1988) evaluated 15 rice varieties and advance breeding line for their reaction to rice stem borer (*S. incertulas*) under medium deep water condition. They found rice germplasms *viz.*, TCA 4 TCA 24 and TCA 19 and TCA 269 were least susceptible, whereas, Barogar 62-10, Barogar-6, TCA 47-2 and TCA 177 were highly susceptible to the stem borer.

Yen and Das (1988) ascertained fourteen promising rice varieties for their reaction to stem borers and observed significantly lower number of white-ear infestation in genotypes IR50, IET7259, IET-3629 and CR-237-1 under unprotected condition.

As per the report of Tiwary *et al.* (1991), three genotypes *viz.* Desaria-3, TCA-47-2 and TCA-182 were found susceptible, whereas TCA-12, TCA-214, TCA-269 and Jaladhi were found least susceptible to *S. incertulas* at vegetative, panicle initiation and maturity stage of rice crop in Bihar.

Riaz *et al.* (1993) screened 16 rice varieties/lines for their resistant to yellow stem borer on the basis of preference or non-preference and antibiosis and recorded lowest dead heart and white earhead infestation in variety TKM-6, Basmati 385 and line 4321 from which TKM-6 and Basmati 385 exhibited non-preference and antibiosis mechanism of resistance, while preference and antibiosis type of mechanism was observed in line 4321.

Senapati *et al.* (1993) evaluated 11 deep water rice varieties under wet trial at Bhubaneswar (Orissa) for their reaction to yellow stem borer and its effect on yield. Out of these, variety Panidhan (CR 151-79 X CR 1014) recorded the highest (2833 kg/ha) grain yield and considered as the most tolerant to yellow stem borer followed by Kalamahipal and Champeisiali.

Sharma and Balkrishna Rao (1993) investigated the yield performance and tolerance of rice varieties to stem borer (*S. incertulas*) under intermediate and semi-deep water condition at Cuttak (Orissa). They recorded negligible incidence of stem borer in cultures R 1014-153, R 1014-283, R 1014-380, R 1014-404, Utkalprabha, MJ 16 and MJ 51 under semi-deep water condition. Same cultures showed much less incidence of *S. incertulas* under intermediate deep-water condition also.

Singh and Pandey (1997) tested 41 rice cultivars to check their relative susceptibility to yellow stem borer, *S. incertulus* and reported that none of the cultivar showed great resistance at vegetative stage. At heading stage, the cultivar IR-72 was found resistant and IR-36 and Ratna were moderately resistant.

As per the report of Korat *et al.* (1998) from Gujarat, rice cultures *viz*; Mo-1, Co-29 and IET-10750 withstands against incidence of major insect pests of paddy, but IET 10750 recorded the significantly high (12.41-14.92 %) incidence of stem borer. Minimum per cent tiller damage by stem borer was observed in variety Masuri (1.64 %), Narmada (4.65 %) and GR-101 (7.97 %) as against 22.50 per cent tiller damage in GR-11 used as a susceptible check.

Gupta *et al.* (2003) screened 30 aromatic rice genotypes in Faizabad (Uttar Pradesh) for checking resistance to rice yellow stem borer and pointed that out of 30 genotypes, 6 were moderately resistant, 20 were moderately susceptible and 4 were susceptible to *S. incertulas*.

According to Korat *et al.* (2003^b), out of six rice cultures (IET-12150, IET-12537, IET14074, SKL-11-28-65, RP-3179-1462 and RP-3174-1631) and two varieties (Jaya and GR-11) tested for their reaction to pests, culture IET-12537, IET14074 and RP-3179-1462 were found free from stem borer attack.

Four genotypes of scented rice *viz.* IET 9691, Redjolele, Pakistan Basmati and Bindli semi dwarf were found resistant to stem borer at vegetative (DH) and reproductive (WE) stages showing antixenosis and antibiosis reaction against yellow stem borer (Mann and Shukla, 2005).

Misra *et al.* (2005) recorded maximum incidence of dead heats and white ears due to stem borer in rice cultivar RAU 869-5-14-1, whereas, that was minimum in Dhanlaxmi and Prabhat.

Dash *et al.* (2007) recorded the incidence of stem borer in rice varieties and the performance of hybrid rice Proagro H-6201 was not found satisfactory. In the experiment, mean white earhead percentage varied from 3.72 to 10.26 per cent in different rice varieties with lowest value in Surendra Hybrid rice H6201 supported highest white earhead (10.26%) than susceptible check Jaya (8.96%).

Singh and Shukla (2007) checked 1224 rice accessions for screening during *Kharif* 2005 against stem borer and 43 accessions were found promising against stem borer. The lines found promising against stem borer were retested in *Kharif* 2006 and only 9 accessions, *viz.*, 333, 1320, 2174, 2696, 2700, 2702, 2738 and 2747 show resistance and the rest 34 were susceptible.

Sumathi *et al.* (2009) showed that entries TM 05063, TM 05011, TM 05015 and TM 05020 were resistant to yellow stem borer.

Out of twelve early, medium and late varieties evaluated against yellow stem borer under irrigated condition, Ratna showed tolerance both at vegetative and reproductive stages (Panigrahi and Rajamani, 2010).

Sankpal (2011) data on per cent dead heart due to *S. incertulas* after 30 days of transplanting revealed that the infestation in different genotypes/varieties varied from 0.95 to 7.53 per cent and none of the genotype was found to be free from infestation. From the genotypes screened, significantly lowest (0.95%) infestation was registered in genotype NWGR-3173 and it was at par with NWGR-4011, NWGR-4009, NWGR-6136 and NWGR-4014 which recorded 1.24, 1.49, 1.61 and 1.64 per cent dead heart, respectively. The paddy variety GR-11 exhibited significantly highest (7.53%) infestation due to *S. incertulas*, followed by variety GR-4 (5.39%) and GR-12 (5.32%). At 15 days before harvesting, significantly highest (23.74 %) infestation was recorded from susceptible check variety GR-11, followed by GR-4 (21.34%) and GR-12 (21.12%).

Gole (2012) showed that the genotypes NWGR-4005, NWGR-4031, NWGR-6108 and Gurjari were found moderately resistant as these genotypes registered DH index in between 11 to 20 %, whereas five genotypes viz., NWGR-5070, NWGR-6050, NWGR-6168, NWGR-7076 and NWGR-7078 were graded as moderately susceptible to stem borer as they exhibited the DH index between 21 and 30 % at 30 Days after transplanting. Variety GR-11 proved as highly susceptible at vegetative stage and the DH index above 60%. While at 50 Days after transplanting, dead heart index of genotypes NWGR-6050, NWGR-6108, NWGR-6168, NWGR-7076, NWGR-7078 and Gurjari were categorized as moderately resistant as these genotypes registered DH index due to yellow stem borer in between 11 to 20%. Variety GR-11 was highly susceptible to yellow stem borer (DH > 60 %). At heading stage, the genotypes/varieties NWGR-6050, NWGR-7078 and Gurjari were categorized as moderately resistant, whereas NWGR-4031, NWGR-5070, NWGR-6168 and NWGR-7074 were graded as moderately susceptible

because their index ranged under 6 to 10 and 11 to 15 per cent, category, respectively. Variety GR-11 was found to be highly susceptible at every stage of the crop showing maximum dead hearts (7.54 % and 13.58 %) and white earheads (23.76 %) damage, respectively.

2.2.2 Green leaf hopper (*N. virescens*):

Sekizawa and Ogawa (1980) studied on rice varieties resistant to green leaf hopper, *N. cincticeps* for nymphs and adults on rice seedlings were showed significant differences in their mortality and preference for different varieties. Varietal differences were also seen in the growth of the nymph and inhibition of plant elongation caused. Values for resistance to *N. impicticeps* were different from those for *N. cincticeps*, indicating that different resistance factors may be involved. Almost all varieties resistant to *N. cincticeps*.

Garg (1997) conducted a field experiment on the density and dispersal pattern of *N. virescens* on 6 varieties of paddy (two susceptible to tungro virus, three resistant and one intermediate). The greatest population number (626 insects) was registered on the most susceptible variety T(N)1, followed by Ratna (372), Jaya (350), IR-20 (298), Mudgo (231) and Vijaya (157).

2.2.3 Brown plant hopper (*N. lugens*):

Pathak and Lal (1976) found variety IR 26 was susceptible against brown plant hoppers in study of varietal screening at International Rice Research Institute, Cuttack.

Mochida *et al.* (1977) studied different varieties of paddy against brown plant hopper of rice at International Rice Research Institute, Manila and showed that variety IR-26 found most susceptible, followed by IR-30 and IR34 while, varieties IR-32 and IR-36 were found resistant.

Domingo (1976) surveyed different rice fields of Central Luzon, Philippines and noted the incidence of brown plant hopper on varieties such as IR-26, IR-32, IR- 36 and IR- 38.

Velusamy *et al.* (1986) evaluated rice varieties IR-5 to IR-64 for resistance to green leaf hopper and plant hoppers at Tamil Nadu Agricultural University, Coimbatore and found that varieties IR-62 and IR-64 were highly resistant to brown plant hopper.

Prakash Rao (1987) identified that the promising rice high yielding cultivars such as CR 233-10, CR-157-1900, CR-333-6-1, culture, 76 and WX- 1014-120 were resistant to brown plant hoppers in dry and wet seasons.

Cohen *et al.* (1997) showed that IR-64 had slight to moderate levels of antibiosis, antixenosis, and tolerance relative to the cultivars IR-22 Azucena, which contain no major genes for *N. lugens* resistance.

Alice and Sujeetha (2001) studied the effect of 7 cultivars of rice against brown plant hopper in a green house at Madurai and observed the highest population on TN 1 with 53 BPH/hill and lowest on ADT 36 with 15 BPH/hill. The number of BPH on TN 1 was on par with ADT 41 throughout the period. The rate of increase was more or less and same up to 45 DAT. The peak density occurred at 60 DAT with 18.00 (lowest) BPH/hill on ADT 36 and 59.33 BPH/hill (highest) on TN 1. The population on CORH 1 and IR-20 was on par during all periods of findings.

In an experiment, Jena *et al.* (2006) found Banaspati, Panidubi, Dhoiyabankoi, Salkathi, Dhobanumberi and Jalkanathi were resistant cultivars to brown plant hopper, out of 337 varieties screened.

Katti *et al.* (2006^a) studied the tritrophic interactions of rice varieties against brown plant hopper and natural enemies in irrigated rice at Hyderabad, wherein they concluded that the variety Vijetha was found resistant variety with highest yield and natural enemies population.

The data of Desai (2008) revealed that all varieties showed more or less per cent damaged hills of rice brown plant hopper. The minimum per cent damaged hills (0.09) was found in variety GR-104, followed by

GR-103, GR-102, GR-101 and IR-66 with 0.12, 0.19, 0.21 and 0.21 per cent damaged hills respectively coincided with scale 1. This was followed by varieties like GR-3, GR-6, GR-7 and Narmada having 0.39, 0.56, 0.58 and 0.69 per cent damaged hills, respectively and were brought under scale 3 as moderately resistant varieties. Ratna, GR-10, IR-22 and GR-12 varieties were found moderately susceptible having 1.02, 1.10, 1.12 and 1.18 per cent damaged hills and are brought under damage scale 5. Varieties IR-28, GR-11 and Masuri were found susceptible with 1.75, 1.75 and 2.10 per cent damaged hills respectively. The maximum per cent damaged hills were found in variety Jaya (3.09), followed by Gurjari (2.58). Based on corrected per cent damage and scale, the varieties having scale 1 were IR-66, GR-101, GR-102, GR-103, GR-104 considered as resistant, varieties having scale 3 were GR-3, GR-6, GR-7, Narmada considered as moderately resistant, varieties having scale 5 were GR-10, Ratna, GR-12, IR-22 considered as moderately susceptible, varieties having scale 7 were IR-28, GR-11, Masuri considered as susceptible and varieties having scale-9 viz., Jaya and Gurjari considered as highly susceptible.

2.2.4 Rice earhead bug (*L. acuta*):

Earlier, Sen and Chaudhari (1959) recorded the maximum infestation of *L. varicornis* Fab. on rice from middle of September to middle of October on *Aus* paddy varieties. They found that the *Aman* paddy varieties which form the major bulk of the crop (70%) escape the attack altogether as its flowering period starts when the pest goes under hibernation.

Diwakar (1975) reported that gundhi bug cause serious damage in late maturing varieties.

Saroja and Raju (1984) evaluated 37 entries of rice against *L. acuta* under field condition, of which IET-5860, Pusa 312, TK M 9 and TNAU-18580, IET-5878 were found moderately resistant to the bug.

Mishra *et al.* (1991) screened 53 different varieties of rice against earhead bug (*L. acuta*) and found that RR-50-3 and RR 19-2 were least susceptible to earhead bug.

Gupta *et al.* (1993) tested five different varieties of rice *viz.*, Heera, Settari, Neela, Kalinga-II and Annada against rice earhead bug and observed that Heera varieties was more resistant, whereas Annada and other up-land variety of 105 days duration showed higher damage (3.39 to 6.21%) than other up-land varieties of short duration.

In the field experiment of Ghule (2006) on varietal screening of rice against rice earhead bug, *L. acuta* taken during August-November (*khari*), the results showed that none of the varieties of rice were found free from incidence of rice earhead bug. For per cent damaged grains, it was found that the lowest grain damage was on TN1 (3.50 %) and was at par with varieties GR-10 (4.00%) and GR-6 (4.50 %). The variety Jaya recorded highest (8.65 bugs/20 hills) population and it was at par with GR-101 (7.65 bugs/20 hills), GR-104 (7.40 bugs/20 hills) and GR-103 (7.35 bugs/20 hills). It was found that the varieties IR-28, GR-10, GR-6, GR-7, GR-3, GR-9, Kada, IR-66, TN1, Gurjari, GR-12 and GR-102 were moderately resistant and the remaining varieties *viz.*, GR-4, GR-5, Ratna, GR-11, Jaya, GR-103, GR-101, Masuri and GR-104 were slightly resistant to earhead bugs. From the experiment, it was found that the incidence of rice earhead bug was greater in mid-late and late maturing varieties as compared to early maturing varieties due to migration of bug from early maturing varieties to late varieties.

Mandape (2013) revealed that difference in per cent damaged grains in different varieties was found significant. However, among all varieties significantly lowest percentage of damaged grains was found in Pawana (1.40%), which was followed by GR-104 (4.31%), GR-9 (6.20%) and IR-22 (6.93%). Significantly highest percentage of damaged grains was found in IR-28 (37.41%), which was at par with IR-50 (32.26%), followed by Jaya (25.78%). As per per cent damaged grains, variety Pawana was resistant having 1 scale, varieties *viz.*, IR-22, GR-9, GR-102

and GR-104 showed moderately resistant reaction having 3 scale while varieties viz., NAUR-1, GR-4, GR-6, GR-7, GR-10, GR-11, GR-12, GR-101, GR-103, Gurjari, Narmada and PR 116 were slightly resistant having 5 scale. The varieties viz., IR-28 and IR-50 were susceptible with scale 7, while remaining varieties viz., IR-66, Dandi, Jaya and PRH-10 showed highly susceptible reaction with scale 9. Thus resistant variety Pawana and moderately resistant varieties viz., IR-22, GR-9, GR-102 and GR-104 can be incorporated in resistance breeding for rice earhead bug.

2.2.5 Rice leaf folder (*C. medinalis*):

Upadhyay *et al.* (1975) evaluated varietal susceptibility of rice leaf folder and observed that variety N-19 appeared to be highly resistant as compared to other varieties viz., J-280, K-118, Jaya and IR-8.

Gowda *et al.* (1981) tested different varieties against leaf folder and among them ARC 25, KMP 133 and KMP 58 showed minimum damage.

Nadarajan and Rajappan (1983) checked 31 cultivars against leaf folder and GEB 24 and PTB were found highly resistant.

Garg (1984) evaluated 31 entries against leaf folder and revealed that the entries IR 9209-26-2-2-2-3, NR 59, PTB 833, TNAU 9039-14, TNAU 929227-1, URP-311-19-2-1, UPR 82-1-7, 343-D.T. and W 1263 were resistant with score 3.

However, Joshi *et al.* (1985) screened 30 rice varieties against leaf folders, *C. medinalis* and *M. pantalis* and observed that ASD5, TKM-6 GEB 24 were resistant to both species.

In another study, Velusamy and Chelliah (1985) evaluated different rice accessions against leaf folders damage and revealed that the genotypes ARC6650, ARC10550, PTB33 and TKM6 were resistant to leaf folders.

Rajendran *et al.* (1986) tested 18 rice accessions against leaf folders damage and recorded RP2068 18 4 5, IR4707 106 3 2, ARC6650, ARC10660, TNAU LFR 832035 and TNAU LFR 831331 were resistant to leaf folders.

While, Medina *et al.* (1986) screened 227 wild rice cultivars against leaf folder and found that accessions no. 101232 and 101236 were highly resistant to *C. medinalis* as well as *M. pantalis*.

In the investigation of Patnaik *et al.* (1987), they reported rice varieties *viz.*, IR 7687 (Masuri/ IR30), IR30/ Suphla, OBS 677/IR2071/ RPB-13/W/1263 were resistant to leaf folder out of 46 cultivars screened at Regional Research Station (RRS) Keonjhar, Orissa.

Rajendran *et al.* (1987) showed good level of leaf folder resistance (Score : 5) in rice varieties *viz.*, PM 585 and PM 1409.

Saroja *et al.* (1987) screened seven entries against leaf folder and the entry BG-367-3 was found highly resistant to rice leaf folder.

While in another trial, Rajendran (1988) screened 26 accessions in the greenhouse as well as in the micro plots and reported rice varieties *viz.*, TNAULFR 831324, TALAULFR 842718 and PTB 33 were highly resistant to leaf folder in both the plots.

As per the report of Sudhakar *et al.* (1991), rice genotypes/cultivars IET 7564, ES-29-3-3-1, Pusa 2-21 and Type -3 were least susceptible while varieties Rashi 17-4B-13, Rajshree, Rashi 16-4B-11 and UPR 238T were highly susceptible to *C. medinalis*.

Thamrin and Rosmini (1993) tested 22 promising lines against leaf folder and found that the line IR 24637-38-2-2 was resistant.

According to Korat and Pathak (1996), Narmada, sukhvel-20, masuri, IR-22 and Nawagam-19 cultivars of rice considered as moderately resistant to leaf folder attack.

Different popular rice varieties of Gujarat were tested against leaf folder and results showed that varieties *viz.*, SK-20, GR-6, IR-28, Ratna, IR-66, SLR-5124, Ambica, GR-102 and Masuri were found tolerant (Anonymous, 1998).

Faleiro *et al.* (2001) evaluated 12 cultivars for the incidence and degree of field resistance to rice leaf folder, *C. medinalis* and reported

that the cultivars Karjat-2-32 and Mahaveera were highly resistance to leaf folder.

Soundararaj *et al.* (2001) reported that ADTRH1 was moderately resistant to leaf folder, *C. medinalis*.

Mishra *et al.* (2002) screened 33 rice varieties against 3 rice leaf folders *viz.*, *C. medinalis* (Pyralidae: Lepidoptera), *Marasmia exiguua* (Pyralidae: Lepidoptera) and *Brachmia arotraea* (Gelechiidae: Lepidoptera) and showed that varieties Parijat, Rudar, Sankar, Khandagiri, Sarathi, Samanta Meher and Rambha were resistant to *B. arotraea* and moderate resistance to *C. medinalis* and *M. exigua*.

Rao *et al.* (2002) evaluated 87 and 82 INRC germplasms during *kharif* 1999 and 2000 and found that INRC 15703, 15708, 15725 and 15732 were resistant to leaf folder during both the seasons.

While, Venkateshwarlu *et al.* (2002) screened 100 rice cultivars for resistance to leaf folder, *C. medinalis* and among them, 22 cultivars recorded a consistent damage indicating rating two, while majority of cultivars with damage rating of five and seven.

Whereas in another experiment, Gupta *et al.* (2003) screened 30 different aromatic rice genotypes against leaf folder and noted that the cultivars NDR 6175, NDR 6093 and NDR 6232 were found to be resistant with 3.1, 1.8 and 3.8% incidence of leaf folder, respectively.

Korat *et al.* (2003^b) showed that the incidence of leaf folder was significantly low in IET-12150 and IET-12537 cultivar than susceptible check Jaya and GR-11 cultivar.

Patel (2006) revealed that all the varieties showed more or less per cent damaged leaves of leaf roller. The minimum per cent damaged leaves was found in variety GR-103 (0.27). The per cent damaged leaves was 0.29 for the variety GR-102, 0.49 for GR-11, 0.49 for IR-28, 0.62 for kada, 0.66 for GR -7, 1.26 for Ratna, 1.43 for GR -3, 1.52 for GR -101, 1.93 for GR -12, 2.27 for GR -1, 2.44 for GR -5, 2.55 for TN-1, 2.79 for

Jaya, 2.91 for GR-9, 3.12 for IR-66, 3.25 for GR-10, 3.38 for GR-6, 3.43 for Gurjari, 3.44 for GR-104 and 3.48 for Masuri.

Misra *et al.* (2006) found that Riccharia cultivar was significantly tolerant to leaf folder damage with mean infestation (4.4%), followed by Prabhat (8.5%).

Ahmed *et al.* (2008) screened the 10 cultivars and 20 advance varietal lines against rice leaf folder and found that none of the genotype was immune escaped leaf folder infestation; however, Ranbir Basmati, IET0-18470, IET-18572, IET-189494, IET-17571, IET-18033, IET-18571 and IET-18572 were moderately resistant.

Nigam *et al.* (2008) tested 25 rice germplasms at different cropping stages (tillering, booting and dough) for resistance to leaf folder, *C. medinalis* and among the entries, 6 germplasms *viz.*, IET 13310, NDR 6023, IET 10649, Mahsuri, NDR 6232 and NDR 6175 showed a consistent damage rating of 1.

Sumathi *et al.* (2009) showed that cultures RIC 050611 and RIC 050613 were resistant to leaf folder.

In the results of Sankpal (2011) for the damage done by leaf folder indicated that the genotype NWGR-7075 exhibited significantly least (12.27%) damage of the leaf folder than all the evaluated genotypes/varieties of paddy. The genotypes IET-21568, NWGR-7028, IET-21582, NWGR-4014, NWGR-4011 and NWGR-6072 registered 12.76, 12.79, 12.83, 12.84, 12.87 and 12.91 per cent leaf damage due to leaf folder, respectively and were found significantly more resistant than remaining genotypes. Among the tested genotypes/varieties, GR-11 showed significantly highest (19.50 %) leaf damage due to *C. medinalis* followed by GR-4(18.50 %) and GR-12(17.98 %).

Gole (2012) reported that the genotype NWGR-4031 and variety Gurjari exhibited significantly least (3.49% and 3.70%) damage of the leaf folder, respectively and statistically at par with each other. The genotype NWGR-6168 registered 4.32 % damage and remained as next best genotype. Genotypes NWGR-6050, NWGR-5070 NWGR-7074,

NWGR-6108, NWGR-4005, NWGR-7076, NWGR-7078 and NWGR-6107 registered 6.11 to 6.59 per cent leaf damage due to leaf folder and were at par with each other. Among the tested genotypes/varieties, GR-11 showed significantly highest (9.55%) leaf damage due to leaf folder, the genotypes/varieties under screening can be placed in increasing order of susceptibility as NWGR-4031 > Gurjari > NWGR-6168 > NWGR-6050 > NWGR-5070 > NWGR-7074 > NWGR-6108 > NWGR-4005 > NWGR-7076 > NWGR-7078 > NWGR-6107 > GR-11.

2.2.6 Rice blue beetle (*L. pygmaea*):

Patel (1977) evaluated 130 genotypes of rice against *L. pygmaea* and found that 27 varieties viz., RP-1-633-200-2-2-1, RP-633(E), I.B.B.N-73, IET-826(8407), IR-579-87-2-3, IARI-10709, IR-8, GR-907, RP-31-47-2, 5-6-1, 12-5-2-4-10, 3-1-3, 1-12-1-3-15, 31-4-3-3-3, 1-29-5-1-2-3, 1-5-1-2-32, 117-2-2-22, Sona, 129902-4, 12903-13, 6-2-1-5, IR-539-48-12, Mania, Jamuna, Krishna, 1-32-4-2, 1-4-33, 1-4-3-6 were proved to be the most tolerant against *L. pygmaea*.

While in another study, Karthikeyan and Jacob (2007) screened 150 varieties against rice blue beetle and reported that the varieties viz., Ptb.1 (Eravanpandy), Ptb.1 (Vellari), Ptb.7 (Parambuvatta), Ptb.9 (Thavalakannan), Ptb.18 (Eravanpandy), Ptb.19 (Anthikkiraya), Ptb.20 (Vadakan chitteni), Ptb.25 (Thonnooran), Ptb.26 (Chenkayamma) and a short duration high yielding variety of Mannuthy (Hraswa) were moderately resistant and 5 varieties/entries viz., Mo 12, IET 17895 (UTR -57), Ptb.39 (Jyoti), Ptb.41(Bharathy) and Varna were found highly susceptible against blue beetle.

Patel (2008) showed that minimum per cent damage leaves due to blue beetle (0.17%) were found in varieties IR-22 and GR-104 coincided with scale 1, followed by per cent damaged leaves 0.19 for GR-102, 0.21 for GR-103, 0.33 for Ratna, 0.36 for GR-7, 0.40 for GR-12, 0.45 for IR-28, 0.67 for GR-10, 0.68 for GR-101, 0.72 for Narmada, 1.29 for Masuri, 1.37 for Jaya, 1.49 for Gurjari, 1.91 for IR-66 and 2.25 for GR-11. The maximum per cent damaged leaves was found in variety GR-3 (2.36).

Based on corrected per cent damage and scale, the varieties having scale 1 were IR-22, GR-102, GR-103 and GR-104 considered as resistant, varieties having scale 3 viz., IR-28, GR-6, GR-7, Ratna and GR-12 considered as moderately resistant, varieties having scale 5 viz., GR-10, Narmada and GR-101 considered as moderately susceptible, varieties having scale 7 viz., Gurjari, Jaya and Masuri considered as susceptible and varieties having scale 9 viz., GR-3, GR-11 and GR-66 considered as highly susceptible.

2.2.7 Rice sheath mite (*S. spinki*):

Rao and Prakash (1985) reported rice varieties like Ratna, Karuna, Savitri, Jaya, Udaya, CR-1014, Vijaya, Pusha 2-21, Kalinga-1, Supriya and Jaganath were highly susceptible to the incidence of mite, *Tyrophagous palmerum* Oudemans.

Karuppuchamy *et al.* (1987) observed that when incidence *Oligonychus indicus* Hirst were severe and population were high, yellowing of the leaves were observed after 50 days of transplanting in rice varieties like ADT-36, TN-1, IR-50, IR-62 and IR-64 in paddy fields in Kerala.

Mukherjee *et al.* (1989) observed no relationship between the physical characters of the leaf and population density of *Oligonychus oryzae* on rice except the leaf width, which had a significant relationship with the mite population.

Rao *et al.* (2000) noticed that varieties viz., MTU-1001, MTU-2067, MTU-2077, MTU-7029, BPT-5204 and PLA-1000 were more affected by *S. spinki* in East and West Godavari districts of Andhra Pradesh during the wet season of 1999.

Bandhaniya (2005) revealed significant differences among rice varieties in two season data. They observed that the early varieties like IR-50 stood top in showing minimum mite incidence (3.49/leaf sheath) and it comparable with GR-3 (4.86/leaf sheath) and IR-28 (5.32/leaf sheath). Whereas, GR-5 recorded moderate incidence (7.21/leaf sheath).

and it was at par with GR-4. While, higher incidence was found in GR-7 (8.06/leaf sheath) and IR-21 (8.09/leaf sheath), but significantly lower than GR-6 on which highest number of mite (13.36/leaf sheath) was recorded. In case of mid late varieties, Masuri ranked first in recording minimum mite incidence (1.42/leaf sheath) and differ significantly from other varieties. The next variety prone to attack was GR-10 and was comparable with GR-101 (6.64/leaf sheath). Varieties like GR-11 (7.17/leaf sheath), Narmada (7.88/leaf sheath) and GR-102 (8.33/leaf sheath) showed moderate mite population and at par with each other. Gurjari (17.70/leaf sheath) and GR-103 (18.45/leaf sheath) found more susceptible to mite incidence, but less than Jaya (28.30/leaf sheath).

The data on mean number of *S. spinki* per leaf sheath recorded at NARP farm, NAU, Navsari showed that the highest incidence was recorded in variety GR-5 (14.30/leaf). It was followed by other varieties viz., Jaya, Gurjari, GR-11 and GR-4, which also showed higher level of mite infestation. Rice varieties/germplams like IR-28, IR-50, IR-66, PRH-10, SPRV-1 SPRV-2, IET-19419 and Lal Kada have no mite incidence throughout the crop season, while rest of the varieties/germplams showed low to medium level of mite infestation (Anonymous, 2014).

2.3 Effectiveness of insecticides against rice yellow stem borer:

Chiu *et al.* (1980) obtained good results against stem borer (*S. incertulus*) with root zone application of nereistoxin derivatives (cartap, dimethypo [of unstated composition] and thiocycalam hydrogen oxalte). This compound act as synaptic blocking agents.

Similarly, Ibrar and Manzoor (1983) observed that the application of cartap (Padan 4G) @ 20 lb per acre 30 and 60 DAT reduced the yellow stem borer infestation and significantly increased yield.

While, Mo *et al.* (1983) reported that cartap gave excellent results (reduction in population of more than 90% as compared with no treatment) against *T. incertulus* (*S. incertulus*).

Peter and David (1988) studied the bioefficacy of cartap hydrochloride against yellow stem borer and reported that cartap 4G @ 900 g *a.i.* / ha and cartap 50 SP @ 375 g *a.i.* / ha applied at 15 days interval commencing from 10 days after transplanting (DAT) gave effective control of rice yellow stem borer, *S. incertulas* and secured the highest grain yield. Sukhija *et al.* (1988) tested different insecticides on yellow stem borer incidence and showed that the treatment with cartap hydrochloride 4 G @ 1.5 kg *a.i.* /ha controlled the rice yellow stem borer, *S. incertulas* and produced highest grain yield.

Khan and Khaliq (1989) tested cartap, carbofuran, diazinon, thiofanox, chlorfenvinphos and chlorpyriphos for the control of *S. incertulas* and other stem borers on rice and in the study cartap was found effective insecticide with higher yield, followed by carbofuran and diazinon.

Vavadia *et al.* (1996) recorded successful control of rice stem borer in Gujarat with carbofuran (0.45 kg *a.i.*/ha), phorate (0.5 kg *a.i.*/ha) and foliar application of fenitrothion 0.04% or monochrotophos 0.04% when applied at 25, 50 and 75 DAT.

Sontakke and Dash (2000) evaluated some of new granular insecticides applied in the nursery 5 days before uprooting and 50 days after transplanting against major pest of rice. Among the test granules, nursery application of isazofos and chlorpyriphos were effective against stem borers causing dead heart infestation. Cartap hydrochloride, fipronil and phorate were ineffective in controlling both the early-stage insect pest of rice. Application of chlorpyriphos, isazofos, ethoprophos, carbofuran and fipronil at 50 DAT afforded effective control of stem borers causing white heads.

Saljoqui *et al.* (2002) reported that the treatments with cartap (Padan) 4G @ 22.23 kg /ha and fipronil (Regent) 300 EC @ 197.6 ml /ha were found most effective in reducing rice yellow stem borer incidence.

Dash and Mukherjee (2003) tested ten insecticides (fipronil 0.075 kg a.i./ha, chlorpyrifos 1.0 kg a.i./ha, carbofuran 1.0 kg a.i./ha, lambda-cyhalothrin 0.0125 kg a.i./ha, amitraz 0.3 kg a.i./ha, imidacloprid 0.025 kg a.i./ha, solafllufen 0.1 kg a.i./ha, methofenozide 0.1 kg a.i./ha, profenofos 0.5 kg a.i./ha and chlorpyrifos 0.5 kg a.i./ha) against major insect pests of rice and reported that fipronil @ 0.075 kg a.i./ha gave maximum protection against gall midge, yellow stem borer, plant hoppers and obtained highest grain yield of 40.4 q/ha, which was at par with carbofuran @ 1 kg a.i./ha.

An experiment was carried out by Panda *et al.* (2004) at Bhubaneswar and recorded superiority of fipronil 0.4G at 30 DAT @ 0.05 and 0.075 kg a.i./ha over carbofuran 3G @ 1.0 kg a.i./ha and phorate 10G @ 1.25 kg a.i./ha in controlling stem borer, BPH and leaf folder infesting rice.

Lal (2006) tested novel cartap hydrochloride 4G against stem borers of rice in Haryana for two consecutive *kharif* seasons. The findings showed that cartap hydrochloride @ 1.0 and 0.75 kg a.i./ha applied at 30, 50 and 70 DAT proved most effective in managing the incidence of stem borers and realizing higher yield of rice grains. Two applications of cartap hydrochloride at 30, 50, and 70 DAT was equally effective to three applications of monocrotophos in managing the incidence of stem borers and realizing higher yield. The cost benefit ratio was highest in monocrotophos (1:8.68), followed by cartap hydrochloride @ 0.75 kg a.i./ha broadcasted at 30 and 50 DAT (1:7.64), but lowest in cartap hydrochloride @ 1.0 and 0.75 kg a.i./ha applied at 50 and 70 DAT (1: 2.80).

Sekh *et al.* (2007) set a experiment to test the efficacy of fipronil 80% WG at different doses against stem borer, *S. incertulas* and leaf folder, *C. medinalis* of rice during *kharif* 2004 and 2005 in West Bengal. The results revealed that fipronil 80% WG @ 40 and 50 g a.i./ha provided highly effective control of stem borer and leaf folder. The WG formulation of firponil was better than the SC formulation of the same

chemical. Other insecticides *viz.*, monocrotophos 36 SL and chlorpyriphos 20 EC were less effective against stem borer and leaf folder of rice.

In another experiment of Desai (2008) observed that imidacloprid 0.005 per cent (11.24%) was found to be most effective and significantly superior than the rest of treatments against rice brown plant hopper and was on par with fipronil 5 per cent (11.75%). The next effective treatments were polytrin-C 0.044 per cent (17.81%), monocrotophos 0.04 per cent (21.14%), mehyl parathion dust 0.05 per cent (22.57%), nimbecidine 0.03 per cent (26.36%), endosulphan 0.04 per cent (28.54%) and chlorpyriphos 0.05 per cent (31.47%) and which were statistically on par with each other.

In another investigation conducted by Karthikeyan *et al.* (2008) to evaluate the efficacy of spinosad 45 SC @ 45 and 54 g a.i./ha in comparison to three other insecticides *viz.*; lambda-cyhalothrin, chlorpyriphos+cypermethrin and monochrotophos against insect pests of rice at Regional Agricultural Research Station, Pattambi, Kerala for three seasons *viz.*, *kharif* 2005, *rabi* 2005 and 2006. They revealed that spinosad @ 54 g a.i./ha caused 63 and 49% reduction in dead hearts and white ears, respectively. They also found that spinosad caused no significant effect on spider population and was safe to spiders that pre-dominate the predatory fauna of rice.

Kuttalam *et al.* (2008) evaluated the relative efficacy of fipronil 80 WDG stem borer of rice. In the investigation, fipronil 80 WDG @ 50 g a.i./ha proved the most effective in reducing the stem borer population. The insecticides @ 40 g a.i./ha recorded minimum dead heart and white ear symptoms, which was at par with fipronil 5 SC @ 50 g a.i./ha. The best treatment in order of their effectiveness were fipronil 80 WDG @ 30 g a.i./ha, chlorpyriphos 20 EC and monocrotophos 36 SC.

Bhutto and Soomro (2009) tested different granular insecticide against yellow stem borer and among these Pasban 4%G proved effective to reduce the dead heart and white earhead percentage and increased

yield. Pasban followed by Dragon 4%G, Advance 5%G (Trifluralin), Croptech 4%G, Angler 4%G and control, respectively.

Dhaka *et al.* (2009) conducted experiment to determine the comparative efficacy of insecticides, biopesticide and botanicals against yellow rice stem borer. The results showed the fipronil 5 SC was best with final infestation of 1.9 per cent dead heart and 45.58 q/ha yield, followed by cartap hydrochloride 4G, *Bt* and neemarin. Regarding predatory population due to application of insecticides showed that the spiders were recorded maximum in control plot and it was 2.35 per hill. Among the different treatments, the maximum number of spiders was found in cartap hydrochloride 50 SP, followed by fipronil 5 SC.

Hugar *et al.* (2009) conducted experiment to evaluate the efficacy of new molecules against *S. incertulas* on rice (cv. Rasi) and at 50 and 75 days after sowing (DAS), application of fipronil 0.3G resulted in the lowest percentage of dead heart (DH) damage (3.40 and 2.43%, respectively). This treatment also resulted in the lowest white earhead incidence (2.59%) and highest grain (42.97 kg/ha) and fodder (61.25 kg/ha) yields, net return (Rs. 14729/ha) and cost: benefit ratio (1: 7.86).

The experimental results of Hugar *et al.* (2010) showed superiority of fipronil 0.3G @ 7.5 g a.i./ha followed by carbofuran 6G @ 1000 g a.i./ha, carbofuran 3G @ 750 g a.i./h, which were moderately effective and cartap hydrochloride 4G @ 1000 g a.i./ha was least effective among the granular formulations.

Singh *et al.* (2010) evaluated bioefficacy of insecticides against stem borer in basmati rice at farmers field and the study revealed that cartap hydrochloride 4G @ 18.75 kg/ha, fipronil 0.3 @ 18.75 kg/ha were comparatively more effective than methyl parathion and monocrotophos.

Kumar and Sachan (2011) tested five newer, two biopesticide and two conventional insecticides against yellow stem borer, *S. incertulas* in aromatic rice. The experiment showed that the application of lambda cyhalothrin @ 25 ml a.i./ha was the most effective treatment in reducing

the stem borer infestation at all observational interval resulting highest yield (44.10 q/ha) and maximum net return and it was followed by indoxacarb @ 36 ml a.i./ha. Among biopesticide, a new molecule spinosad @ 200 ml a.i./ha was found more effective.

Gole (2012) extracted that of the seven insecticidal treatments along with control evaluated against *S. incertulas* in paddy, the insecticide flubendiamide 20 WG + buprofezin 20 SC (35+175 g a.i./ha) was found best with lowest (5.60 %) dead hearts. Flubendiamide 20 WG (35 g a.i./ha) remained second best and showed lower (6.59 %) dead hearts, while cartap hydrochloride 4 G (1000 g a.i./ha) also registered lower (7.46%) dead hearts but they were not at par with each other. Among the other tested insecticides, buprofezin 25 SC (175 g a.i./ ha), acephate 95 SG (562.5 g a.i./ha), fipronil 5 SC (50 g a.i./ha) and profenophos 40% + cypermethrin 4% EC (440 g a.i./ha) registered 9.08, 9.34, 9.46 and 9.76 % dead hearts, respectively and at par with each other. The data obtained on per cent white earheads recorded revealed that flubendiamide 20 WG + buprofezin 20 SC (35+175 g a.i./ha) recorded the lowest (3.36%) damage and was at par with cartap hydrochloride 4 G (1000 g a.i./ha) and flubendiamide 20 WG (35 g a.i./ha) which registered 4.43 and 4.55 per cent white earheads, respectively. Fipronil 5 SC (50 g a.i./ha), acephate 95 SG (562.5 g a.i./ha) and buprofezin 25 SC (175 g a.i./ ha) were at par with each other and recorded 7.08, 7.19 and 8.37% white earheads, respectively. Profenophos 40% + cypermethrin 4% EC (440 g a.i./ha) registered 9.63 per cent white earheads followed by buprofezin 25 SC (175 g a.i./ ha). Highest white earheads were recorded in control plot (16.76%). The grain yield of paddy in all the insecticidal treatments was significantly higher over control (2230.7) and it was varied from 3192 to 4410.7 kg/ha. Flubendiamide 20 WG + buprofezin 20 SC (35+175 g a.i./ha) recorded highest (4410.7 kg/ha) grain yield. The next effective treatment with respect to grain yield was cartap hydrochloride 4 G (1000 g a.i./ha) with 3889 kg/ha grain yield. Treatment with buprofezin 25 SC (175 g a.i./ ha), fipronil 5 SC (50 g a.i./ha), flubendiamide 20 WG (35 g a.i./ha), acephate

95 SG (562.5 g a.i/ha) and profenophos 40% + cypermethrin 4% EC (440 g a.i/ha) registered 3492.7 to 3192.3 kg/ ha grain yield and found at par with each other.

2.4 Evaluation of different modules for management of rice pest complex:

Satpathi *et al.* (2005) conducted on-farm trails to assess *in situ* losses due to key pest and quantify the role of natural biological control in rice in West Bengal. Estimation of biological control and natural enemies population was done under three treatments *viz.*, Natural Biological Control (NBC), Need Based Pesticide application (NBP) and Scheduled Based Pesticide (SBP) application in 30 farmer's field in 30 villages. The results revealed SBP showed significantly less incidence of yellow stem borer, green leaf hopper and brown plant hopper. Among natural enemies, higher levels of *Lycosa pseudoansulata* spider and predatory beetle, *Ophionea nigrofasciata* population were observed in NBC treatment compared to NBP and SBP. However, there were no adverse effect on population of predatory bug, *Cyrtorhinus lividipennis* in SBP treatment which showed significantly higher levels than NBC and NBP. In terms of grain yield and economics, despite highest yield in SBP, the NBP treatment was the best treatment showed higher cost benefit ratio at five sites and was superior to SBP and NBC as it also harboured more natural enemies.

Katti *et al.* (2006^b) carried out on farm adaptive trails to develop and verify location specific IPM technologies suitable for rainfed rice production system in Orissa, West Bengal, Andhra Pradesh and North Eastern states of Assam and Manipur during wet season. The results indicated that incidence of insect pest was lower in IPM (with a set of optimized location specific pest control components adopted on need basis) and scheduled treatment (ST) (Application of insecticides based on a regular schedule) than farmer's practices (FT) (involving conventional practices of the farmers. The cost benefit ratio was higher in IPM treatment providing higher net returns to farmers. There was also

increase in natural enemy population in IPM treatments due to reduction in pesticide use.

Dwivedi *et al.* (2007) compared bio-control based IPM module with chemical and farmer's practice for yellow stem borer and the results revealed that the bio-control based IPM module with components *viz.*, summer ploughing, clipping of leaf tips before transplanting, recommended dose of N:P:K (60:30:30) and 6 release of *Trichogramma japonicum* @ 50,000 ha release at weekly interval starting from 30 days after transplanting showed superiority over the chemical control and farmer's practice.

Farmer's participatory on-farm trial was conducted by Maitri *et al.* (2007) on integrated pest management (IPM) schedule for upland rice during wet seasons in five locations of Jharkhand state. The investigation revealed that the adoption of IPM package significantly enhanced rice grain in both improved (44.6%) and traditional (41.1%) varieties with highest average grain yield of 2.24 t/ha in Vandana grown under improved practice. Improved practice with variety Vandana also showed higher benefit: cost ratio (average 0.61) with higher return over paid out cost.

Mohapatra (2008) conducted as on-farm research trail on biointensive management of basmati rice (Pusa Basmati-1) in farmers participatory mode with three treatments comprising of farmer's practice (FP), Chemical based pest management (CBP) and Integrated pest management (IPM) in four villages having two locations in each village. The results showed that IPM crop suffered with less incidence of insect pests *viz.*, stem borer (2.43%), leaf folder (4.2%) and grasshopper (2.24%) in contrast with farmer's pest management practices in which crop suffered with stem borer (5.12%), leaf folder (7.68%) and grasshopper (4.53%). Similarly, IPM plot recorded highest yield and cost benefit ratio in comparison to FP and CBP.

Patel *et al.* (2009) carried out a experimental study during the *Kharif* 2000 to 2004 in Nawagam, Gujarat to evaluate the efficacy of

integrated pest management (IPM) against *C. medinalis* on rice (cultivars Gurjari and GR-11 for the farmers practices and IPM treatments, respectively). Under the investigation, they were treated the seeds of Gurjari with Streptomycin sulfate and Emisan, whereas the seeds of GR-11 were not treated. Similarly, seedlings of Gurjari were transplanted at recommended spacing (20 × 15 cm) and treated with recommended rates of chemical fertilizers (100:25:0::N:P:K kg/ha), whereas seedlings of GR-11 were transplanted randomly and supplied with slightly higher rates of chemical fertilizers (125:25:00::N:P:K kg/ha). The results revealed that IPM exhibited a lower incidence of *C. medinalis* (3.60%) than farmer's practices (7.0%).

A field experiment was conducted on Farm Integrated Pest Management during *Kharif* 2010 at Karjat. Under this trial, the four modules contained insecticide based module (IPM Module I containing summer ploughing, clipping of leaf tips of seedling before plating, application of carbofuron 3G @ 16.5 kg/ha 55 DAT, fertilizer dose 100:50:50::N:P:K kg/ha), non insecticide based module (IPM Module II containing summer ploughing, clipping of leaf tips of seedlings before planting, growing pest tolerant variety, fertilizer dose 100:50:50::N:P:K kg/ha, installation of 20 pheromones traps/ha and changing the lures 3 times at 25 days interval starting from 15 DAT), insecticide + non insecticide based module (IPM Module III containing summer ploughing, clipping of leaf tips of seedlings before planting, application of carbofuron 3 G @ 16.5 kg/ha 55 DAT, fertilizer dose 100:50:50::N:P:K kg/ha, installation of 20 pheromones traps/ha and changing the lures 3 times at 25 days interval starting from 15 DAT) and farmers practices (IPM Module IV containing summer ploughing, growing high yielding variety, conventional farmers practices, fertilizer dose 100:00:00::N:P:K kg/ha.), respectively were followed. Among the four modules, the module III was found superior and recorded 2.2% dead hearts at 45 and 55 DAT, respectively also showed minimum white earhead damage (5.3%) (Anonymous, 2010^c).

Karthikeyan *et al.* (2010) conducted field experiments on farmer's rice field in Karakkad village, Pattambi, Kerala during 2006-07 to 2008-2009 with 3 rice IPM modules (IPM I, IPM II and IPM III) in comparison with farmers' practices to validate and popularize the IPM modules in rice. The results showed that the IPM III module comprised alternate spraying with neem-based formulation and newer safer insecticide (cartap hydrochloride and spinosad) coupled with release of egg parasitoids against leaf folder and monitoring of stem borer with sex pheromone traps resulted in significant reduction of stem borer (3.88% dead heart, 1.95% white ear), whorl maggot (4.10% damaged leaves) and leaf folder (2.73% damage leaves). However, stem borer incidence was reduced by 61.6% in IPM III modules as compared with farmer's practices. Leaf folder damage has showed a reduction of 64.8% and whorl maggot infestation indicated 61.03% reduction in IPM III module over farmer's practices.

Elakkiya *et al.* (2011) tested IPM modules to control rice leaf folder complex during *kharif* 2010 and *rabi* 2011 in the coastal region of Karaikal, wherein they showed that per cent leaf damage was less in eco-friendly IPM module in both the seasons with components *viz.*, application of NSKE 5%, *Bacillus thuringiensis*, *Beauveria bassiana*, Spinosad, release of *Trichogramma chilonis* and erection of bird perches.

While, Mahal *et al.* (2011) laid out experiment to check different Integrated Pest Management techniques based on scientifically proven component for the control of stem borer and leaf folder in large scale field trials at farmer's field in village Sudhar (Distt. Ludhiana) and revealed that IPM model-I (Traps + chemical control) gave higher economic returns than IPM model-II (Traps + tricho-cards + chemical control). In both the models, the incidence of leaf folder (0.12-0.38%) and stem borer (0.30-1.22%) was lower than farmer's practices (1.19% leaf folder and 1.29-3.42% stem borer damage).

In another experiment Mishra and Sharma (2012) validated integrated pest management module against yellow stem borer, S.

incertulas in basmati rice at farmer's field in village of Murchipur of Faizabd and compared with farmer's practice (Non-IPM) during wet seasons. The trial with IPM schedule with eight components *viz.*, summer ploughing, early transplanting by 25th July, clipping of seedling tips before transplanting, recommended doses of fertilizer (90N:40P:30K), plant spacing with 20x 10 cm mass trapping of yellow stem borer with pheromone traps @ 20 traps ha⁻¹, proper drainage and single application of cartap hydrochloride 4g (75 g a.i./ha) at economic threshold level showed their superiority over farmer's practices. The IPM module resulted 34-39% increase in grain yield with mean increase of 36.79% over non-IPM plots. The results proved the cost effectiveness of tested IPM module over farmer's practice with 1:1.92 cost benefit ratio.

CHAPTER III

MATERIALS AND METHODS

Rice is one of second most intensively grown cereal crop next to wheat and ranks third in grain production. But, it is facing various pest problems starting from seedling to maturity stage. Implication of integrated pest management is one of the best strategies to overcome these problems. Keeping this view in mind and to justify the objective, research work on the study of seasonal incidence, varietal screening, effectiveness of insecticides against yellow stem borer of paddy and evaluation of different management modules against rice pest complex and under South Gujarat condition were carried out at Wheat Research Station Farm, N.A.U., Bardoli during the *Kharif* 2012 and 2013.

The materials used and methodology adopted in these investigations are presented briefly in this chapter under different headings and subheadings.

3.1 Seasonal incidence of rice pest complex in relation to different methods of planting and its correlation with weather parameters

3.1.1 Experimental details:

- | | |
|-----------------------|---|
| 1. Location | : Wheat Research Station Farm, N.A.U., Bardoli |
| 2. Season and year | : <i>Kharif</i> 2012 and 2013 |
| 3. Design | : Randomized Block Design (RBD) |
| 4. Area of experiment | : 1000 m ² |
| 5. Variety | : NAUR-1 |
| 6. Spacing | : Conventional: 20 cm x 15 cm
SRI: 25 cm x 25 cm |
| 7. Method of sowing | : Transplanting |

8. Fertilizer application : Conventional: 100 : 30 : 00 :: N: P: K
kg/ha
SRI: 40-15-00 :: N: P: K kg/ha
9. Age of seedling : Conventional: 25 days old
SRI: 12 days old

3.1.2 Cultural operations:

All the post sowing recommended agronomical practices were followed. However, experimental area was kept free from insecticide spray throughout the crop season in order to record the seasonal incidence of paddy pests.

3.1.3 Method of observation:

The following two methods were utilized for taking observations on seasonal incidence of insect pests of paddy.

1. Conventional method (Transplanting)
2. SRI method (12 days old seedlings)

3.1.3.1 Rice yellow stem borer (*Scirpophaga incertulas* Wlk.)

The observations of yellow stem borer, *S. incertulas* infestation were recorded at weekly interval till harvesting. The borer incidence was assessed by counting number of dead hearts in the initial stage of damage and number of white earheads at later stage from five randomly selected spots consisting of five hills each as well as from all the clumps in each plot. Both the dead hearts and white earheads were removed from the infested tillers so that only fresh infestation of the pest can be realized every time.

3.1.3.2 Green leaf hopper (*Nephotettix virescens* Distal)

To know the incidence of green leaf hopper, *N. virescens* the observations were recorded by counting total number of nymph and adults on twenty randomly selected spots each comprising five hills at weekly interval. Similarly, to assess the damage intensity the observations were recorded by counting the total number of damaged



Plate No. 1: Experimental view of plot of seasonal incidence of rice pest complex under conventional and SRI methods of planting



Plate No. 2: Experimental view of plot of Conventional method of planting



Plate No. 3: Experimental view of plot of SRI method of planting

and healthy hills from randomly selected twenty spots of one m² area. The spots were selected by walking “M” or “W” fashion in the field.

3.1.3.3 Brown plant hopper (*Nilaparvata lugens* Stal.)

To assess the infestation of brown plant hopper, the observations were recorded by counting total number of nymph and adults on twenty randomly selected spots each comprising five hills at weekly interval. Similarly, to assess the damage intensity the observations were recorded by counting the total number of damaged and healthy hills from randomly selected twenty spots of one m² area each. The spots were selected by walking “M” or “W” fashion in the field.

3.1.3.4 Rice earhead bug (*Leptocorisa acuta* Stal.)

To know the incidence of rice earhead bug *L. acuta* on rice, the observations were recorded as per standard week throughout the crop season. The observations were taken by sweeping insect collecting net five times across the crop canopy from randomly selected field and number of nymph and adults of rice earhead bug were counted.

3.1.3.5 Rice leaf folder (*Cnaphalocrocis medinalis* Guenee)

To know the incidence of rice leaf folder, *C. medinalis* on rice, the observations were recorded as per standard week from 15 days after transplanting till harvest. The observations were taken by counting the number of damaged leaves and total number of leaves from randomly selected five spots consisting of five hills in each spot.

3.1.3.6 Rice blue beetle (*Leptispa pygmaea* Baly)

To assess the damage caused by rice blue beetle (*L. pygmaea*), the observations were recorded as per standard week starting from 15 days after transplanting till harvest. The observations were recorded by counting the number of damaged leaves and total number of leaves from randomly selected twenty spots, each consisting of five hills. The data thus obtained were converted to per cent infestation. Similarly, the observations for adult were also recorded as per standard week starting from 15 days after transplanting till harvest by counting the number of adults remain on the twenty randomly selected spots of one m² area, each spot consisting of five hills then the average population per plant

were calculated. The spots were selected by walking in 'M' or 'W' fashion in the field.

3.1.3.7 Rice sheath mite (*Steneotarsonemus spinki* Smiley)

To record the sheath mite (*S. spinki*) incidence, five spots of one m² area were selected randomly each one from four corners and one from centre at all five locations. To determine the mite population and intensity of damage during dough stage, ten leaf sheaths were sampled from mite infested plants from each spot. The samples were brought to the laboratory in polythene bags. The number of eggs and other active stages of mite present in leaf sheaths were observed under binocular microscope and recorded. The length of area on leaf sheath were measured with the help of scale and noted. Such observations were recorded at weekly interval starting from 15 days after transplanting and continued until crop maturity.

3.1.3.8 Bio-Agents:

3.1.3.8.1 Predators:

A. Spiders:

Numbers of spiders effective upon different pests were counted as per standard week starting from 30 days after transplanting till harvest. For this purpose twenty spots were selected randomly consisting each of five hills. The population of spiders was averaged per hill.

3.1.3.8.2 Parasitoids:

A. Egg parasitoid:

To know the population of egg parasitoid, if any from five spots each having one m² area were randomly selected. For this purpose, collection of egg masses were made at weekly interval in predetermined field. The field collected egg masses were brought to the laboratory and kept separately in plastic container (5 cm X 3 cm) to observe the emergence of parasitoid.

B. Larval parasitoid:

To know the population of larval parasitoid, if any from five spots each having one m² area were randomly selected. For this purpose, collection of larvae along with leaves were made at weekly interval in

predetermined field. The field collected larvae were brought to the laboratory and kept separately in plastic container (5 cm X 3 cm) to observe the emergence of parasitoid. The emerged parasitoids, if any were stored in 70% alcohol.

3.1.4 Population dynamics and its correlation with weather parameters:

In order to study the effect of the weather parameters, *viz.*, maximum temperature, minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, sunshine hours, rainfall and rainy days on population of rice pests, correlation coefficient was worked out. The weekly meteorological data recorded at Wheat Research Station Farm, N.A.U., Bardoli during the *Kharif* 2012 and 2013 between July to October period were utilized for this purpose (Appendix - I and II). The simple correlation was worked out.

3.2 Varietal response against rice pest complex:

To screen out different rice varieties against rice pest complex, a field experiment was laid out and the details of screening trials are furnished as under:

3.2.1 Experimental Details:

1. Location : Wheat Research Station Farm, N.A.U., Bardoli
2. Season and year : *Kharif* 2012 and 2013
3. Design : Randomized block design (RBD)
4. No. of Varieties : 18
5. Replication : 3
6. Plot size : Gross Plot size (6 × 4.2 m²)
Net plot size (5.6 × 3.9 m²)
7. Spacing : 20 cm × 15 cm
8. Method of sowing : Transplanting
9. Fertilizer application : 100-30-00 :: N: P: K kg/ha



Plate No. 4: Experimental view of plot of varietal screening of rice pest complex



Plate No. 5: Different varieties of rice under screening against rice pest complex

3.2.2 Details of varieties used for their reaction against major insect pests:

Sr. No.	Early varieties	Mid-late varieties	Late varieties
1.	GR-7	GR-11	Masuri
2.	GR-12	GNR-2	GR-101
3.	Gurjari	IR-22	GR-102
4.	GNR-3	Jaya	GR-103
5.	NAUR-1		GR-104
6.	GAR-1		Narmada
7.	GAR-2		
8.	IR-28		

3.2.3 Cultural operations:

All the transplanting operations were followed as per recommendations of the University. However, crop was kept free from insecticide spray.

3.2.4 Method of Observations:

The methodology for recording observation on rice pest incidence was same as mentioned in 3.1.3 of experiment no.1. The scale and reaction for resistance/susceptibility score was judged by using Standard Evaluation System for Rice (SES) for the insect pest (Anonymous, 1996^b) which is as under.

3.2.4.1 Yellow stem borer (*S. incertulas*):

Observations on incidence of stem borer were recorded at two stages of the crop *i.e.*, first at vegetative stage and second at pre-maturity stage. Total number of tillers and number of dead hearts from 5 hills/genotype/variety were recorded at 30 and 50 days after transplanting and percentage of dead hearts were worked out. At pre-maturity stage of crop *i.e.*, 15 days before harvest, total number of panicle bearing tillers as well as white earheads were recorded on 5 hills/genotype/variety and per cent white earhead damage was worked out.

Data, thus obtained were subjected to appropriate transformation and statistically analyzed for interpretation. Per cent dead hearts and white earheads were calculated by using following formula.

$$\text{Per cent dead heart/white earhead} = \frac{\text{No. of dead heart / white earhead}}{\text{Total number of tillers (Dead heart + healthy tillers)}} \times 100$$

The per cent dead heart/white earhead of individual test entry was converted in to dead heart/white earhead index which was computed as follows (Singh and Pandey, 1997).

$$\text{Per cent dead heart/white earhead index} = \frac{\text{Dead heart / white earhead (\% in test entry)}}{\text{Dead heart / white earhead (\% in susceptible check)}} \times 100$$

Sr. No.	% Dead heart	% White earhead	Scale	Reaction
1.	0	0	0	HR (Highly Resistant)
2.	1-10 %	1-5 %	1	R (Resistant)
3.	11-20 %	6-10 %	3	MR (Moderately Resistant)
4.	21-30 %	11-15 %	5	MS (Moderately Susceptible)
5.	31-60 %	16-25 %	7	S (Susceptible)
6.	61 % and above	26 % and above	9	HS (Highly Susceptible)

3.2.4.2 Green leafhopper (*N. virescens*):

The damage intensity of paddy leaves due to GLH was counted by examining selected hills. Observations were recorded at weekly interval from 10 randomly selected hills till harvest of paddy crop.

Sr. No.	% damage hills	Scale	Reaction
1.	0	0	HR (Highly Resistant)
2.	1 – 10	1	R (Resistant)
3.	11 – 25	3	MR (Moderately Resistant)
4.	26 – 50	5	MS (Moderately Susceptible)
5.	51 – 75	7	S (Susceptible)
6.	76 - 100	9	HS (Highly Susceptible)

3.2.4.3 Brown plant hopper (*N. lugens*):

The damage done by BPH to the leaves was recorded by visual examination of selected hills. These observations were made at weekly interval from 10 randomly selected hills till harvest of paddy crop.

Sr. No.	% damage hills	Scale	Reaction
1.	0	0	HR (Highly Resistant)
2.	1 – 10	1	R (Resistant)
3.	11 – 25	3	MR (Moderately Resistant)
4.	26 – 50	5	MS (Moderately Susceptible)
5.	51 – 75	7	S (Susceptible)
6.	76 - 100	9	HS (Highly Susceptible)

3.2.4.4 Earhead bug (*C. medinalis*):

The observations were made at weekly interval starting from appearance of the pest. The total number of grains and damaged grains by earhead bug were counted on five randomly selected panicles from each plot and then percentage of damage grain was calculated.

Sr. No.	% damaged grains per panicle	Scale	Reaction
1.	No damage	0	HR (Highly Resistant)
2.	Less than 3 %	1	R (Resistant)
3.	4-7 %	3	MR (Moderately Resistant)
4.	8-15 %	5	MS (Moderately Susceptible)
5.	16-25 %	7	S (Susceptible)
6.	26-100 %	9	HS (Highly Susceptible)

3.2.4.5 Leaf folder (*C. medinalis*):

To assess the damage done by leaf folders, the observations were recorded as per standard week starting from 30 days after transplanting till harvest. The observations were taken by counting the number of damaged leaves and total number of leaves from randomly selected five

spots consisting of five plants in each spot. The data thus obtained were converted to per cent infestation. Corrected per cent damage was calculated from formula given by (Garg, 1984).

$$\text{Corrected \% damage} = \frac{\% \text{ damaged leaves in test entry}}{\% \text{ damaged leaves in susceptible check}} \times 100$$

Sr. No.	% damaged leaves	Scale	Reaction
1.	0 %	0	HR (Highly Resistant)
2.	1-10 %	1	R (Resistant)
3.	11-20 %	3	MR (Moderately Resistant)
4.	21-35 %	5	MS (Moderately Susceptible)
5.	36-50 %	7	S (Susceptible)
6.	51-100 %	9	HS (Highly Susceptible)

3.2.4.6 Blue Beetle (*L. pygmaea*):

The damage caused by rice blue beetle was recorded as per standard week starting from 15 days after transplanting till harvest. The observations were recorded by counting the number of damaged leaves and total number of leaves from randomly selected twenty spots, each consisting of five hills. The data thus obtained were converted to per cent infestation. The corrected per cent damage was calculated from formula same as given above in the leaf folder.

Sr. No.	% damaged leaves	Scale	Reaction
1.	0 %	0	HR (Highly Resistant)
2.	1-10 %	1	R (Resistant)
3.	11-25 %	3	MR (Moderately Resistant)
4.	26-50 %	5	MS (Moderately Susceptible)
5.	51-75 %	7	S (Susceptible)
6.	76-100 %	9	HS (Highly Susceptible)

3.2.4.7 Sheath mite (*S. spinkii*):

To record the sheath mite (*S. spinkii*) incidence, five spots of one m² area were selected randomly each one from four corners and one from centre at all five locations. For determining the mite population and intensity of damage during dough stage, ten leaf sheaths were sampled from mite infested plants from each spot. The samples were brought to the laboratory in polythene bags. The varieties were grouped into different categories as method described by Panda (1979). The grouping was done on the basis of range of value calculated by considering the general mean ($\bar{X}$) and the standard deviation (S.D.) of mean population counts of mite.

Sr. No.	Range value of particular parameter	Group
1.	Varieties having value of particular parameter less than $\bar{X} - \text{S.D.}$	Promising varieties
2.	Varieties having value of particular parameter between $\bar{X} - \text{S.D.}$ to $\bar{X}$	Less susceptible varieties
3.	Varieties having value of particular parameter between $\bar{X}$ to $\bar{X} + \text{S.D.}$	Moderately susceptible varieties
4.	Varieties having value of particular parameter more than $\bar{X} + \text{S.D.}$	Highly susceptible varieties

3.3 Effectiveness of insecticides against rice yellow stem borer:

3.3.1 Experimental details:

1. Location : Wheat Research Station farm, N.A.U., Bardoli
2. Duration : 4 months
3. Season and year : *Kharif* 2012 and 2013
4. Variety : GR-11
5. Design : Randomized Block Design (RBD)

6. No. of treatments : 5
7. Replication : 6
8. Plot size : Gross Plot size (6 × 4.2 m²)
Net plot size (5.6 × 3.9 m²)
9. Spacing : 20 cm × 15 cm
10. Method of sowing : Transplanting
11. Fertilizer application : 100-30-00 :: N: P: K kg/ha

3.3.2 Details of treatment:

Sr. No.	Name of insecticide	Formulation	Concentration (%)
1.	Profenophos	50 EC	0.075 %
2.	Fipronil	0.3 G	0.01%
3.	Spinosad	45 SC	0.009%
4.	Cartap hydrochloride	4 G	0.2%
5.	Control (water)	--	--

3.3.3 Cultural operations:

All the post sowing recommended agronomical practices were followed.

3.3.4 Time and method of insecticide application:

The insecticide formulations were used as a foliar spray by using “knapsack sprayer” at the time of peak post population.

3.3.5 Method of observations:

The observations on number of tillers damaged by yellow stem borer (Dead Heart (DH)/White Earhead) were recorded before and 3, 7 and 10 days after application of each treatment. For this purpose, twenty hills were selected randomly from each plot. The percentage of dead hearts were worked out by using following formula.

$$\text{Per cent DH} = \frac{\text{Number of DH}}{\text{Total number of tillers}} \times 100$$



Plate No. 6: Experimental view of plot of different insecticides tested against rice yellow stem borer



Plate No. 7: Experimental view of plot of different IPM Modules evaluated against rice pest complex

3.3.6 Yield:

The grain yield per hectare was recorded for each treatment and data were subjected to appropriate statistical analysis for interpretation.

3.4 Evaluation of different modules for management of rice pest complex:

3.4.1 Experimental details:

1. Location : Farmer's field
2. Duration : 4 months
3. Season and year : *Kharif* 2012 and 2013
4. Design : Randomized block design (RBD)
5. No. of treatments : 5
6. Replication : 6
7. Plot size : Gross Plot size ($6 \times 4.2 \text{ m}^2$)
Net plot size ($5.6 \times 3.9 \text{ m}^2$)
8. Spacing : $20 \text{ cm} \times 15 \text{ cm}$
9. Method of sowing : Transplanting
10. Fertilizer application : 100-30-00 :: N:P:K kg/ha

3.4.2 Cultural operations:

All the post sowing recommended agronomical practices were followed to grow the crop.

3.4.3 Module Details:

The details of different modules are furnished here under:

3.4.3.1 Module IPM-I (Chemical based module):

- Application of Carbofuran 3 G @ 10 kg/1000 sq. m. in nursery at 15 days after sowing.
- Application of Carbofuran 3 G @ 0.75 kg *a.i.* (25 kg) per ha for stem borer at 45 days after transplanting

- Spray application of cartap hydrochloride 50 SP @ 300 g a.i. per ha (600 g formulated product) at 45 and 60 DAT against stem borer and leaf folder and imidachloprid 200 SL @ 25 g a.i. per ha (150 ml formulated product) per ha against plant hoppers at 45 and 60 DAT.

3.4.3.2 Module IPM-II (Non-chemical based module):

- Growing rice yellow stem borer tolerant varieties Ratna.
- Pheromone mediated mass trapping by installing pheromone traps with 5 mg lure @ 20 per ha with changing of lures every 20-25 days against stem borer.
- Field release of *Trichogramma chilonis* @ 1,00,000 parasitised *Corcyra* eggs/ha, 5-6 times starting from 15 DAT against leaf folder or *Trichogramma japonicum* @ 1,00,000 parasitised *Corcyra* eggs/ha, 5-6 times starting from 15 DAT against yellow stem borer.
- Spray application of NSKE 5% at 25, 45 and 65 DAT against yellow stem borer.

3.4.3.3 Module IPM-III (Chemical + Non-chemical based module):

- Application of carbofuran 3G @ 10 kg /1000 sq.m. in nursery at 15 days after sowing.
- Pheromone mediated mass trapping by installing pheromone traps 5 mg lure @ 20 per ha with changing of lures every 20-25 days, starting from 15 DAT against stem borer.
- Field release of *Trichogramma chilonis* @ 1,00,000 parasitized *Corcyra* eggs/ha, 5-6 times staring from 15 DAT against leaf folder.
- Spray application of imidacloprid 17.8 SL @ 25 g a.i. (150 ml formulated product) per ha against plant hoppers.
- Spray application of NSKE 5% at 25, 45 and 65 DAT against yellow stem borer.

3.4.3.4 Module IPM-IV (Spot application):

- Use of concerned insecticides for the control of rice pest only in the infested spots of the field. Plots were examined weekly to judge the initiation and spots of damage so as to apply the insecticides.

Pest	Insecticide	Concentration (%)
Yellow stem borer	Carbofuran 3 G	0.75 kg a.i./ha
Plant hoppers	Imidacloprid 17.8 SL	0.005 %
Blue beetle	Monocrotophos 36 SL (spot application)	0.036 %
Rice defoliator	Monocrotophos 36 SL (whole field)	0.036 %

3.4.3.5 Module IPM-V (Farmer's practice):

- Summer ploughing.
- Growing high yielding varieties like NAUR-1.
- Conventional farming practices including plant protection measures *viz.*, clipping of leaf tips of seedlings before transplanting, application of Carbofuran 3 G @ 0.75 kg a.i./ha in nursery at 15 days after sowing, *etc.*

3.4.4 Method of observations:

Per cent dead hearts of rice yellow stem borer from 20 spots were counted at weekly interval and white earhead at pre harvest stage were recorded. Population of adult blue beetle per plant from 20 spots were counted. Damaged leaves of rice leaf folders were counted at weekly interval. Similarly, damaged hills by green leaf hoppers and brown plant hoppers were also counted from same 20 spots.

3.4.5 Observations to be recorded:

Observations on pest incidence at 10 day intervals (Commencing from 15 DAT) were recorded on 10 randomly selected hills in each replication. Record number of tillers damaged by stem borer (Dead Heart (DH)/White Earhead), number of damaged leaves with leaf folder, plant hoppers, natural enemies, earhead bug from the selected hills. Computing the insect damage was as follows:

$$\text{Per cent DH} = \frac{\text{Number of DH}}{\text{Total number of tillers}} \times 100$$

$$\text{Per cent damaged leaves} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

3.4.6 Yield:

The grain yield per hectare was recorded for each treatment and the benefit cost ratio was calculated by considering the total cost required for plant protection in each module.

Table 1: Details of insecticides evaluated against major insect pests of rice

Sr. No.	Common name	Trade Name	Formulation	Conc. (%)	Dose (kg or lit)	Source
1.	NSKE	Gronim	-	1%	30 ml/ 15 lit	Neem Biocide Plant,Vill. Jahangirpura, Hadgud,P.O. Gopalpura, Anand-388370
2.	Carbofuran	Furadan	3 G	0.75 kg a.i./ha	25 kg/ ha	Nagarjuna Agrichem Limited, Hyderabad-500082
3.	Imidacloprid	Confidor	17.8 SL	0.005%	2.8 ml/ 10 lit	Bayer Crop Science Limited,Mumbai-400076.
4.	Monocrotophos	Nuvacron	36 SL	0.036%	1 ml /lit	Syngenta Ind. Ltd., Mumbai.
5.	Profenophos	Curacron	50 EC	0.075%	1.5 ml /lit	Novartis India Ltd., Mumbai.
6.	Fipronil	Regent	0.3 G	0.001%	3.33 ml /lit	Tata Rallis Pvt. Ltd., Mumbai
7.	Spinosad	Tracer	45 SC	0.009%	0.2 ml/lit	Bayer Crop Science Limited, Mumbai-400076.
8.	Cartap hydrochloride	Padan	4 G	0.2 kg a.i.	5 kg/ ha	Dhanuka Pesticides Ltd., Gurgaon, Haryana
9.	Cartap hydrochloride	Caldan	50 SP	0.05%	1 gm/ lit	Dhanuka Pesticides Ltd., Gurgaon, Haryana

CHAPTER IV

RESULTS AND DISCUSSION

Rice, *Oryza sativa* Linnaeus is one of the oldest and the most important food and livelihood crops of India. Being a staple food crop, rice is facing various pest problems starting from seedling to maturity stage. Rice crop is affected by many insect species, out of which, twenty are of major economic significance. Implication of integrated pest management is one of the best strategies to overcome these problems. The knowledge regarding time of appearance of pest and period of its maximum activity helps the farmers to implement preventive and effective control measures. Keeping this view in mind, research work on the study of seasonal incidence, varietal screening, effectiveness of insecticides against yellow stem borer and evaluation of different management modules against rice pest complex under South Gujarat condition was carried out at Wheat Research Station Farm, N.A.U., Bardoli during *Kharif* season of 2012 and 2013.

The important results derived from these investigations are summarized in this chapter under different headings and subheadings.

4.1 Seasonal incidence of rice pest complex in relation to different methods of planting and its correlation with weather parameters

A study about the influence of different planting methods on seasonal incidence of major pest *viz.*, rice yellow stem borer, green leaf hopper, brown plant hopper, earhead bug, leaf folder, blue beetle and sheath mite build up and their succession was conducted on rice. The simple correlation was analyzed between seasonal incidence of pest complex and weather factors. This experiment was carried out with conventional and SRI method of paddy cultivation during *Kharif* season of 2012 and 2013 and the results of the same are discussed as under.

4.1.1 Seasonal incidence of rice pest complex in relation to different methods of planting:

4.1.1.1 Rice yellow stem borer (*Scirpophaga incertulas* Wlk.):

A. Conventional method (Transplanting):

i. I year (*kharif* 2012):

The per cent dead hearts (DH) before panicle initiation and white ear heads (WEH) after panicle initiation of yellow stem borer, *S. incertulas* were recorded at weekly interval according to standard weeks. The data presented in Table 2 and in Fig. 1 revealed that the incidence of stem borer initiated from 32nd standard meteorological week (SMW) *i.e.* first week of August (0.71% DH) with the peak infestation at 36th SMW (5.17% DH) during *Kharif* 2012. Furthermore, the fluctuations in the incidence were recorded, which again reached second peak during first week of October (40th SMW) with 5.86% WEH. The incidence of yellow stem borer was found till 42nd SMW (2.82% WEH).

ii. II year (*Kharif* 2013):

The incidence of yellow stem borer during second year (Table 2 and Fig. 1) was also started at first week of August *i.e.* 32nd SMW with 0.60% DH and gain peak infestation 5.98% DH at first week of September (36th SMW) in conventional method of planting. Later, the incidence was decline and again recorded second peak at first week of October *i.e.* 40th SMW (5.71% WEH), which further showed the damage till 42nd SMW (1.55% WEH).

iii. Pooled:

It can be seen from the pooled data (Table 2 and Fig. 1) that the *S. incertulas* infestation (0.66%) DH was appeared from first week of August (32nd SMW) and reached to its first peak of 5.58% DH during first week of September (36th SMW). Thereafter, infestation declined gradually and found to be minimum and again increased during late stage of crop growth and found maximum (5.79% WEH) during 1st week of October (40th SMW) and formed second peak.

In earlier studies on seasonal incidence, Sarkar and Gayen (1992) observed two major peaks of *S. incertulas* adults, one in October-November and another during February in West Bengal. More or less similar conclusions have been drawn by Tripathy *et al.* (1999), in which they observed two broods of *S. incertulas*, of which first was during the last week of September and another during 2nd week of November, which coincided with the dough stage of rice in Bhubaneswar. Thus, the present findings are more or less in conformity with the earlier reports. In contrast to this, Kumar and Sudhakar (2001) from Rajendranagar (A.P.) reported the peak activity of yellow stem borer in 2nd fortnight of October during *Kharif* season. Rai *et al.* (2002) also revealed the peak occurrence of yellow stem borer during first fortnight of October. These contrasts might be due to the effect of difference in climatic conditions and cultural practices of a particular locality. However, Kharat (2006) recorded the increased incidence of stem borer from 32nd SMW (August) and it started declining from 42nd SMW (October). Likewise, Saikia (2009) investigated that the stem borer moth population increased from mid August to mid October. The similar type of *S. incertulas* seasonal incidence fluctuation trend was recorded by Sankpal (2011), where the activity was observed from 3rd week of August to 2nd week of November showing peak level during 2nd week of September at vegetative stage and 2nd week of November at reproductive stage. Likewise, Gole (2012) stated the incidence of *S. incertulas* from second week of August (32nd SMW) up to the harvest of the crop, whereas, Justin and Preetha (2013) at Thirupathisaram (Kanyakumari) district showed that the infestation of *S. incertulas* was found during August-September and December-February. These earlier reports on pest occurrence strongly support the results of present investigation.

B. SRI method:

i. 1 year (*Kharif* 2012):

The incidence of the stem borer in SRI method (Table 2 and Fig. 1) was initiated from first week of August (32nd SMW) with 0.52% DH and

gained two peak at first week of September *i.e.* 36th SMW (4.34% DH) and at last week of September *i.e.* 39th SMW (5.16% WEH) and then decline and ended on 42nd SMW (1.46% WEH).

Table 2: Seasonal incidence of rice yellow stem borer in Conventional and SRI Method during *Kharif* 2012 and 2013

Month	Std. Meteorological Weeks	% DH and % WEH of yellow stem borer					
		Conventional Method			SRI Method		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
JULY	28	0.00	0.00	0.00	0.00	0.00	0.00
	29	0.00	0.00	0.00	0.00	0.00	0.00
	30	0.00	0.00	0.00	0.00	0.00	0.00
	31	0.00	0.00	0.00	0.00	0.00	0.00
AUG.	32	0.71	0.60	0.66	0.52	0.40	0.46
	33	1.33	1.96	1.65	1.04	0.75	0.90
	34	2.14	2.33	2.24	1.81	1.38	1.60
	35	3.08	3.86	3.47	2.37	3.45	2.91
SEPT.	36	5.17	5.98	5.58	4.34	4.04	4.19
	37	4.52	4.62	4.57	3.91	3.98	3.95
	38	4.92	5.03	4.98	4.21	3.82	4.02
	39	5.73	5.63	5.68	5.16	4.70	4.93
OCT.	40	5.86	5.71	5.79	4.53	3.14	3.84
	41	3.44	2.66	3.05	2.42	1.64	2.03
	42	2.82	1.55	2.19	1.46	1.05	1.26
	43	0.00	0.00	0.00	0.00	0.00	0.00

ii. II year (*Kharif* 2013):

During *kharif* 2013, the infestation of stem borer was also started from 32nd SMW (0.40% DH), which reached maximum on 36th SMW (4.04% DH) and 39th SMW (4.70% WEH). This infestation then started declining and was observed till third week of October (42nd SMW) with 1.05% WEH. The incidence of stem borer was comparatively less during second year trial (Table 2 and Fig.1).

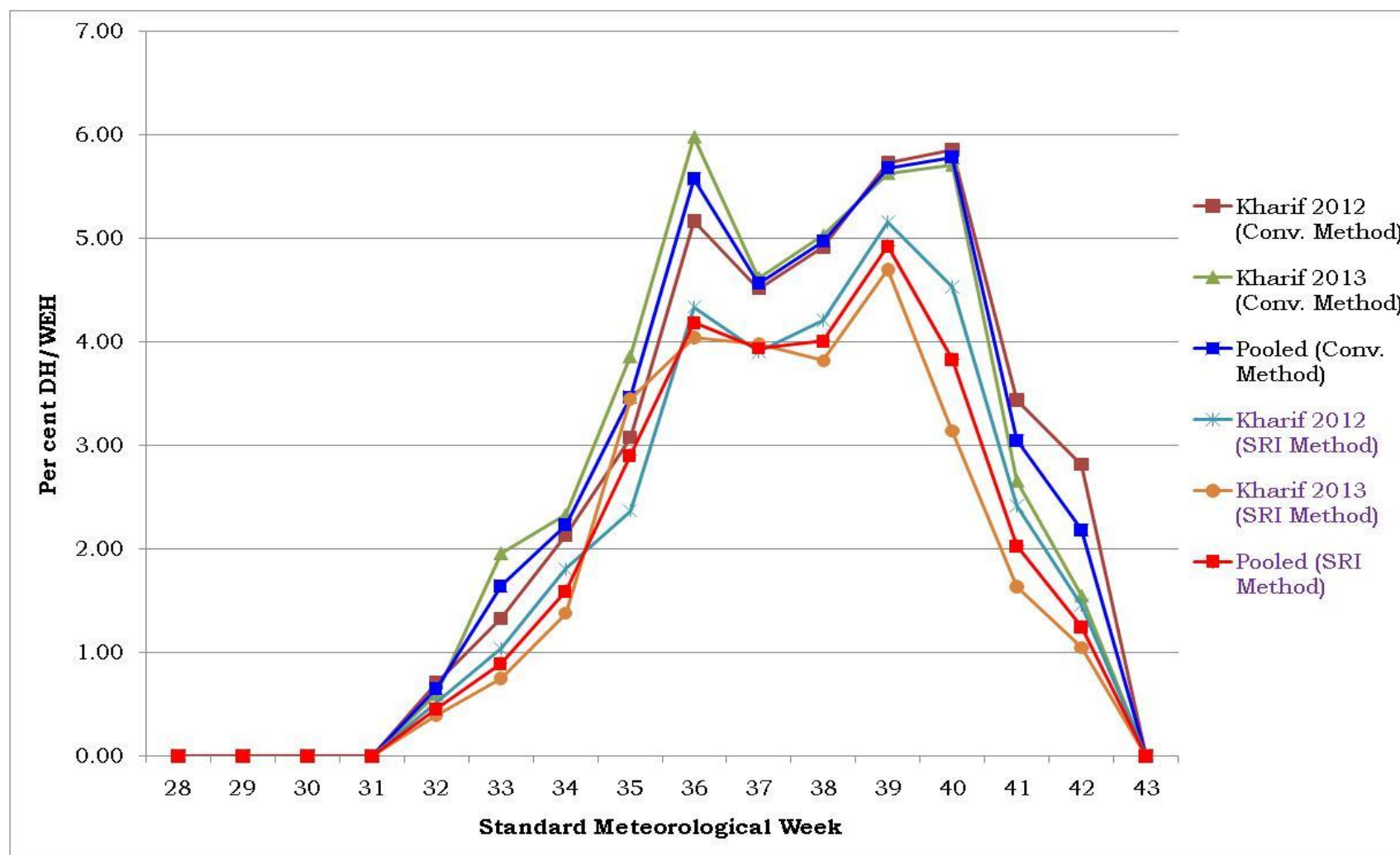


Fig. 1: Seasonal incidence of rice yellow stem borer in Conventional and SRI Method



Plate No. 8: Adult of rice yellow stem borer (*Scirphphaga incertulas*)



Plate No. 9: Dead heart damage in field due to rice yellow stem borer (*S. incertulas*)



Plate No. 10: White earhead damage in field due to rice yellow stem borer (*S. incertulas*)

iii. Pooled:

The pooled results of the stem borer per cent DH and WEH in SRI method is presented in Table 2 and Fig.1. The initiation of stem borer incidence in SRI method was seen from first week of August (32nd SMW) with 0.46% DH. Thereafter, the incidence increased and gained two peaks; first 4.19% DH was recorded at first week of September (36th SMW) and second 4.93% WEH at last week of September (39th SMW). Further, this infestation turn down and observed up to the harvest with minimum infestation of 1.26% WEH at 42nd SMW. The infestation of stem borer was less in SRI method as compared to conventional method of planting.

In earlier work of researches, SRI planting method (Anonymous, 2009 and Anonymous, 2010^b) registered the lowest incidence of *S. incertulas*, while transplanted paddy recorded higher population of this pest. Similar type of trend was also observed in this study. Likewise, Gole (2012) recorded the lowest per cent dead hearts due to *S. incertulas* in SRI (2.51%) as compared to Standard Transplanting Method (STP) (4.47%). Also, the lowest per cent white earheads due to *S. incertulas* were found in SRI (1.22%) than STP method (2.93%). These results confirm the present study.

4.1.1.2 Green leaf hopper (*Nephotettix virescens* Distal)

A. Conventional method (Transplanting):

i. I year (*Kharif* 2012):

The data of *Kharif* 2012 presented in Table 3 and Fig. 2-3 showed that the hill damage (0.25%) and nymphs & adults population of (1.32/hill) of rice green leaf hopper was observed from first week of September (36th SMW). The gradual increase in infestation and population was recorded and the peak stage of per cent hill damage (2.24%) and population (11.15/hill) was observed during first week of October (40th SMW). Later on, the incidence started to decline and observed till harvest of the crop (43rd SMW).

ii. II year (*Kharif* 2013):

The second year data (Table 3 and Fig. 2-3) of rice green leaf hopper revealed that the hill damage (0.32%) and the population of nymphs and adults (2.40/hill) was also started from first week of September (36th SMW). The gradual increase in infestation and population was recorded after 36th SMW and reached peak level of hill damage (2.54%) and the population (12.95/hill) during first week of October (40th SMW). Further, the incidence declined and observed till 43rd SMW with 1.82% hill damage and 7.30/hill nymph and adults population.

iii. Pooled:

Rice green leaf hopper pooled data recorded in conventional method of planting are presented in Table 3 and Fig. 2-3 showed the fact that the hill damage (0.29%) and the population of nymphs and adults (1.86/hill) was initiated from first week of September (36th SMW). This infestation and population of nymphs and adults showed increasing graph after 36th SMW and the peak stage of per cent hill damage (2.39%) and the population (12.05/hill) was observed during first week of October (40th SMW). The amount of severity of the pest was seen at the flowering, dough and grain formation stages of the crop in conventional method of planting. Thereafter, the incidence started declining and observed till harvest of the crop (43rd SMW).

Shamim *et al.* (2009) from Middle Gujarat region showed that green leaf hopper attained peak population during 43rd SMW, which support the present trial results.

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI method of planting, the rice green leaf hopper data (Table 3 and Fig. 2-3) showed that the hill damage (0.23%) and the population of nymphs and adults (0.98/hill) was initiated from first week of September (36th SMW). Further, the incidence and population was

gradually increased and the peak stage of per cent hill damage of 2.04% and the population of 9.02/hill was reached during first week of October (40th SMW). Thereafter, the incidence started to decline and observed till harvest of the crop (43rd SMW) with 1.12% hill damage and 4.80 nymphs and adults/hill.

ii. II year (Kharif 2013):

The rice green leaf hopper seasonal incidence results during *kharif* 2013 presented in Table 3 and Fig. 2-3 revealed that the hill damage (0.25%) and the population of nymphs and adults (1.30/hill) was started from first week of September (36th SMW). Thereafter, the hill damage and the population was found gradually increasing with maximum per cent hill damage of 2.22% and the population of 8.44/hill was recorded during first week of October (40th SMW). Further, the incidence showed decline infestation till harvest of the crop (43rd SMW).

iii. Pooled:

The pooled seasonal incidence and the population data of rice green leaf hopper under SRI method of planting (Table 3 and Fig. 2-3) revealed that the hill damage (0.24%) and the population of nymphs and adults (1.14/hill) was initiated from first week of September (36th SMW). Thereafter, the hill damage and the population gradually increased and the peak stage of per cent hill damage (2.13%) and the population (8.73/hill) was observed during first week of October (40th SMW). The intensity of the pest damage was also seen at the flowering, dough and grain formation stage of the crop in SRI method of planting. Later on, the incidence of yellow stem borer started decline and found till harvest of the crop (43rd SMW) and showed hill damage of 1.16% and population of 4.93/hill.

However, the infestation level and the population of rice green leaf hopper under SRI method of planting was found comparatively less than conventional planting method.

Table 3: Seasonal incidence of rice green leaf hopper (GLH) in Conventional and SRI Method during *Kharif* 2012 and 2013

Month	Std. Weeks	Per cent hill damage by GLH						Average nymphs and adults population of GLH					
		Conventional Method			SRI Method			Conventional Method			SRI Method		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
JULY	28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AUG.	32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEPT.	36	0.25	0.32	0.29	0.23	0.25	0.24	1.32	2.40	1.86	0.98	1.30	1.14
	37	0.70	0.94	0.82	0.68	0.70	0.69	2.40	3.65	3.03	1.38	2.52	1.95
	38	1.36	1.68	1.52	1.10	1.22	1.16	5.48	6.70	6.09	4.44	4.55	4.50
	39	1.79	2.36	2.08	1.42	1.91	1.67	8.28	9.55	8.92	6.22	7.02	6.62
OCT.	40	2.24	2.54	2.39	2.04	2.22	2.13	11.15	12.95	12.05	9.02	8.44	8.73
	41	1.98	2.31	2.15	1.63	1.66	1.65	10.90	11.70	11.30	7.72	7.30	7.51
	42	1.80	1.95	1.88	1.58	1.25	1.42	9.45	9.52	9.49	6.25	6.16	6.21
	43	1.38	1.82	1.60	1.12	1.20	1.16	6.12	7.30	6.71	4.80	5.05	4.93

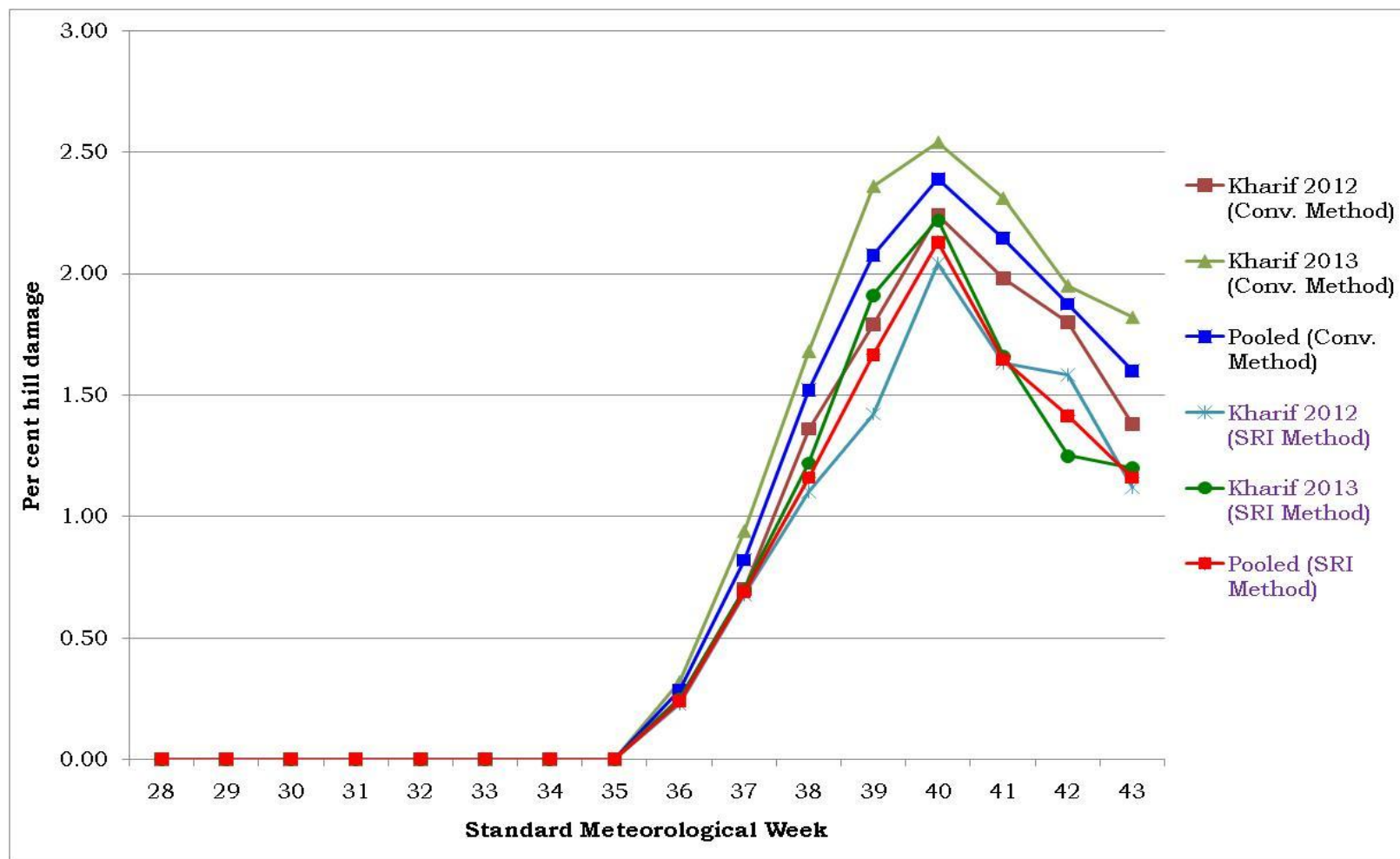


Fig. 2: Seasonal incidence (% hill damage) of rice green leaf hopper in Conventional and SRI Method

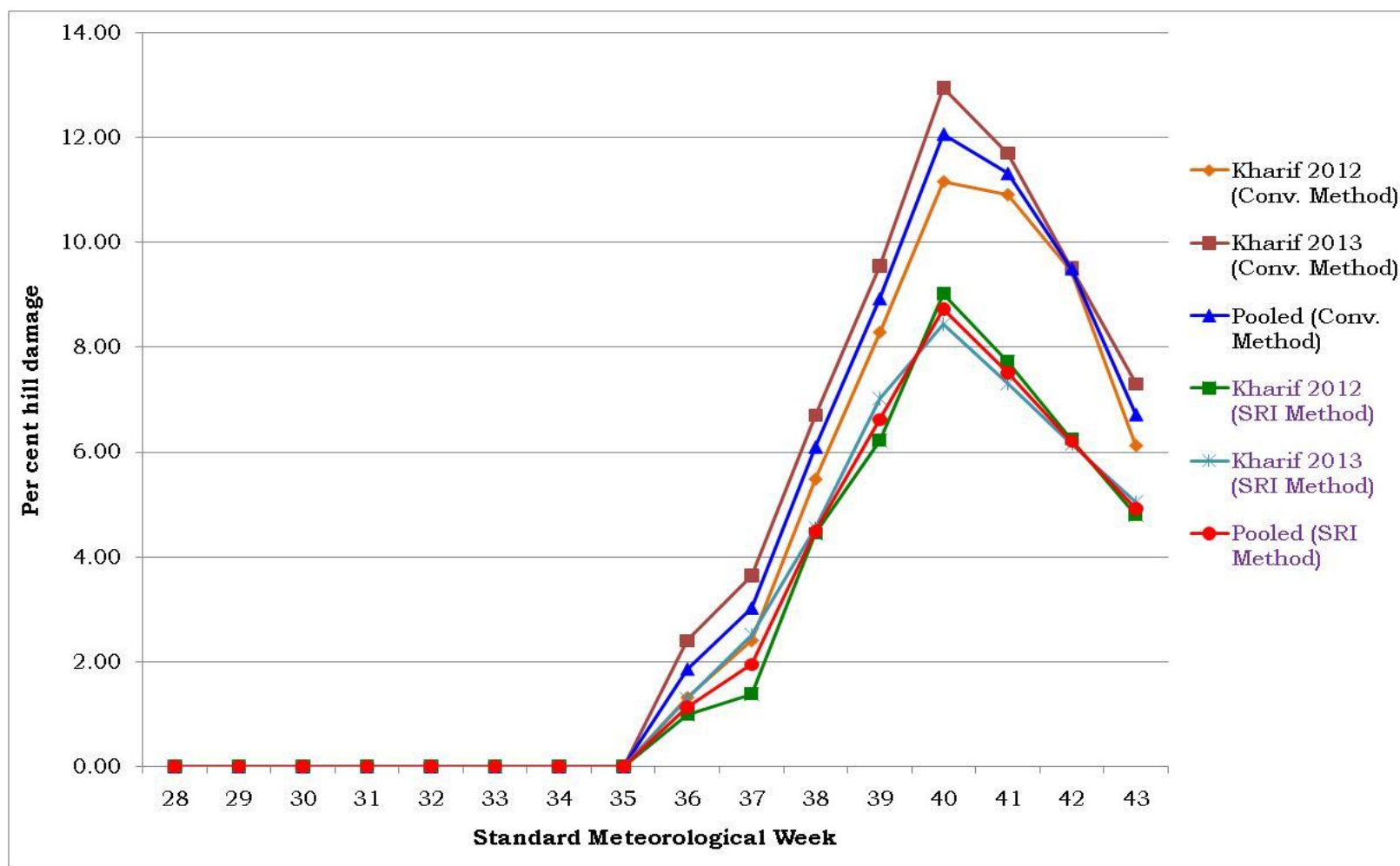


Fig. 3: Seasonal incidence (nymph and adults/hill) of rice green leaf hopper (GLH) in Conventional and SRI Method

4.1.1.3 Brown plant hoppers (*Nilaparvata lugens* Stal.)

A. Conventional method (Transplanting):

i. I year (*Kharif* 2012):

The data of *Kharif* 2012 presented in Table 4 and Fig. 4-5 shown the fact that the hill damage (0.48%) and the population of nymphs and adults (0.62/hill) of rice brown plant hopper was initiated from first week of September (36th SMW). The gradual increase in infestation and population was observed and the peak stage of per cent hill damage (2.72%) and population (3.12/hill) was observed during first week of October (40th SMW). Later on, the incidence was declining and observed till harvest of the crop (43rd SMW).

ii. II year (*Kharif* 2013):

The second year data (Table 4 and Fig. 4-5) of brown plant hopper showed that the hill damage (0.40%) and the population of nymphs and adults (0.55/hill) was started from first week of September (36th SMW). The increased infestation and population was recorded after 36th SMW and reached peak level of hill damage (2.92%) and the population (3.22/hill) during first week of October (40th SMW). Later on, the incidence was declined and observed till harvest of the crop (43rd SMW).

iii. Pooled:

Pooled data recorded regarding brown plant hopper in conventional method of planting presented in Table 4 and Fig. 4-5 has shown the fact that the hill damage (0.44%) and the population of nymphs and adults (0.59/hill) was initiated from first week of September (36th SMW). The infestation and population of nymphs and adults showed increasing graph after 36th SMW and the peak stage of per cent hill damage (2.82%) and the population (3.17/hill) was reached during first week of October (40th SMW). The amount of severity of the pest was seen at the reproductive stage of the crop in conventional method of planting. Thereafter, the incidence declined and observed till harvest of the crop (43rd SMW).

Table 4: Seasonal incidence of rice brown plant hopper (BPH) in Conventional and SRI Method during *Kharif* 2012 and 2013

Month	Std. Meteor. Weeks	Per cent hill damage by BPH						Average nymph and adult population of BPH					
		Conventional Method			SRI Method			Conventional Method			SRI Method		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
JULY	28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AUG.	32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEPT.	36	0.48	0.40	0.44	0.24	0.18	0.21	0.62	0.55	0.59	0.32	0.25	0.29
	37	0.92	0.83	0.88	0.70	0.72	0.71	0.98	1.02	1.00	0.39	0.55	0.47
	38	1.83	1.95	1.89	1.52	1.36	1.44	1.55	1.68	1.62	1.46	1.15	1.31
	39	2.42	2.72	2.57	2.36	2.47	2.42	2.62	2.84	2.73	2.36	2.72	2.54
OCT.	40	2.72	2.92	2.82	2.00	2.25	2.13	3.12	3.22	3.17	2.26	2.62	2.44
	41	2.26	2.46	2.36	1.96	1.87	1.92	2.95	3.05	3.00	2.06	2.44	2.25
	42	2.12	2.25	2.19	1.68	1.73	1.71	2.60	2.78	2.69	1.92	1.88	1.90
	43	1.76	1.92	1.84	1.48	1.63	1.56	1.92	2.25	2.09	1.36	1.68	1.52

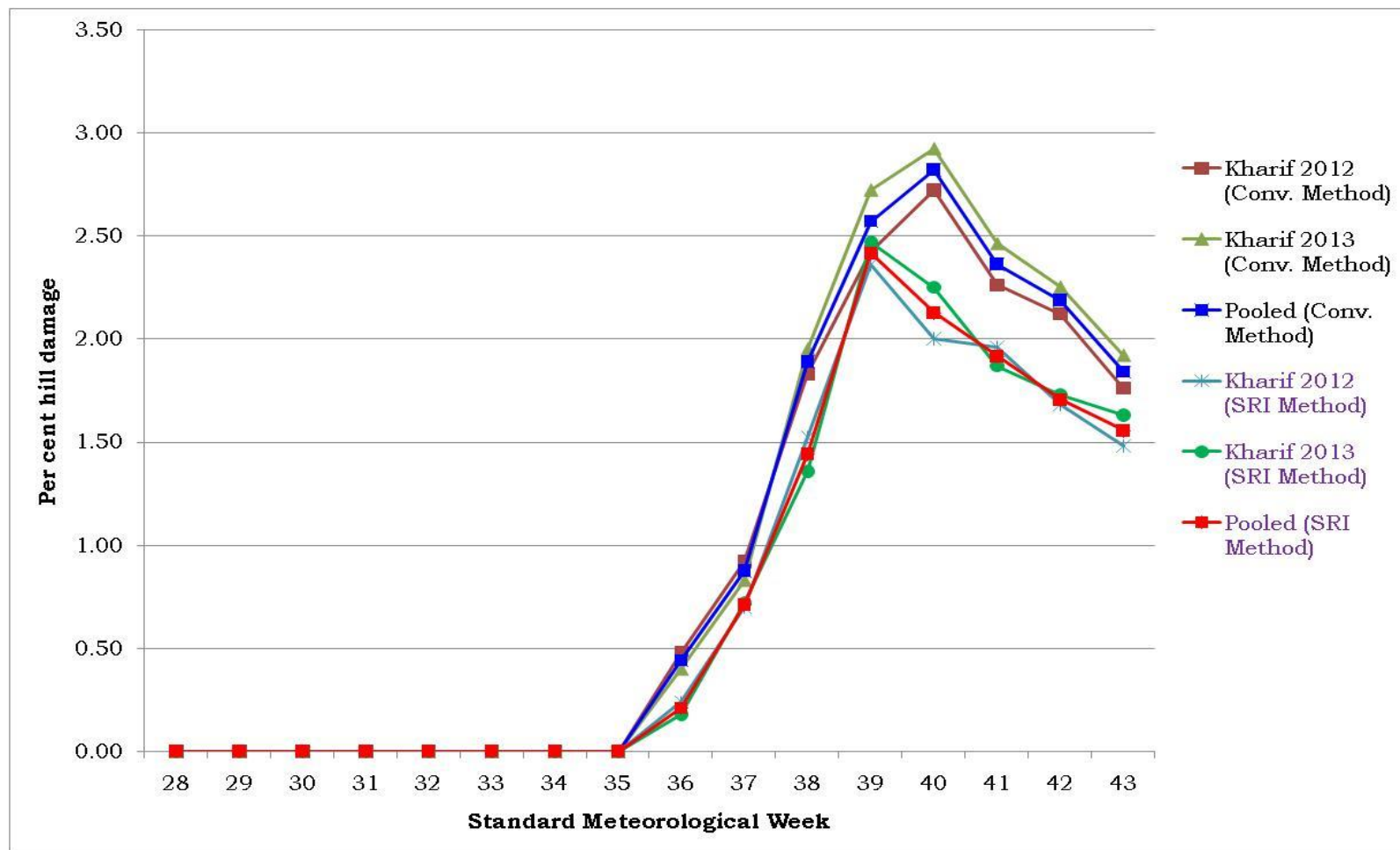


Fig. 4: Seasonal incidence (% hill damage) of rice brown plant hopper in Conventional and SRI Method

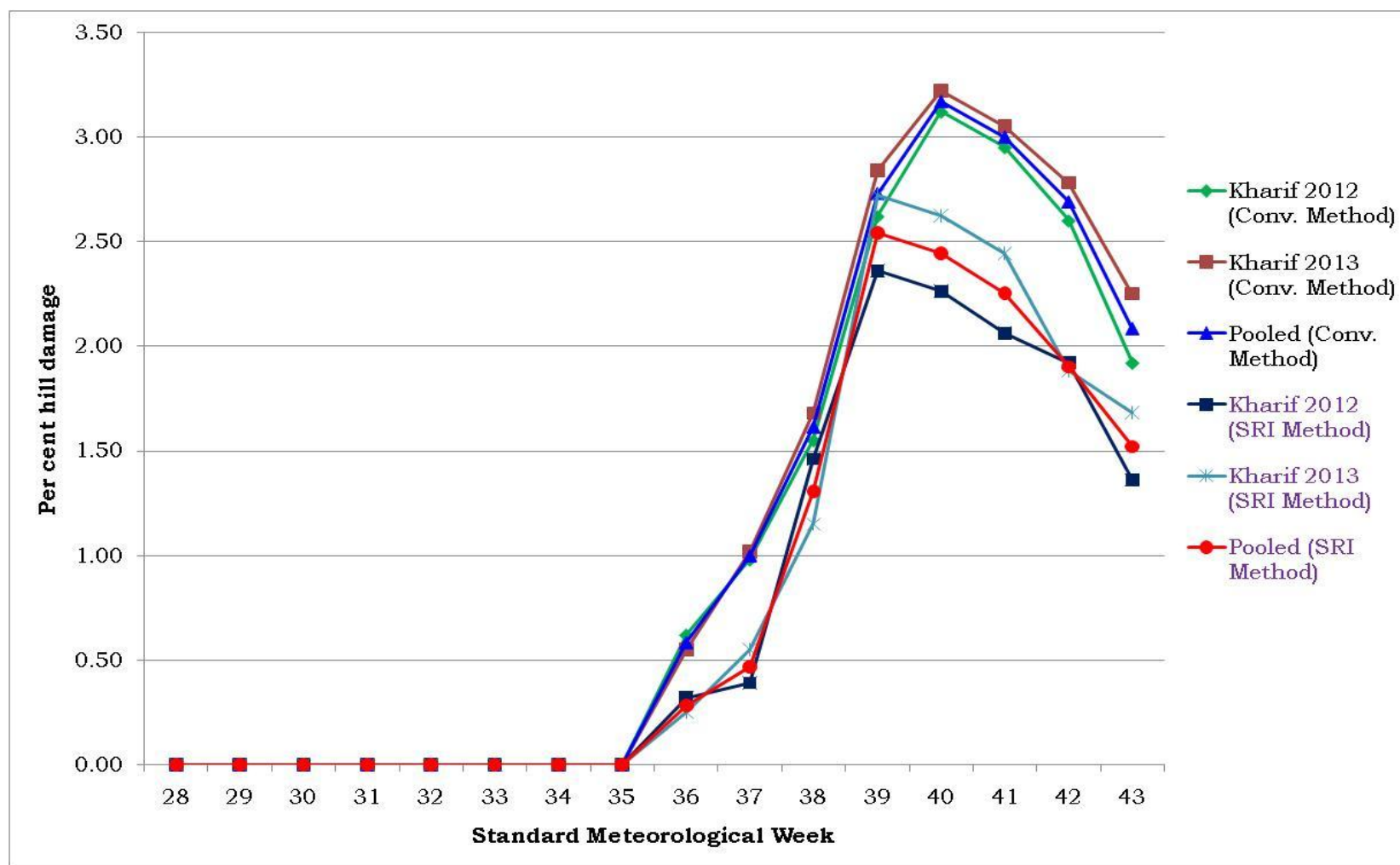


Fig. 5: Seasonal incidence (nymph and adults/hill) of rice brown plant hopper in Conventional and SRI Method



Plate No. 11: Nymph and adult of brown plant hopper (*Nilaparvata lugens*) on rice leaf and stem



Plate No. 12: Adult of Earhead bug (*Leptocorisa acuta*) on rice panicle in field

These results are concerned with the findings of Khaire and Dumbre (1984) wherein they found that the adults were first appeared in mid September and reached to peak numbers in November coinciding with flowering, dough and grain formation stages. Similar results were also reported by Jeyarani (2004) wherein he noticed maximum damage of brown plant hopper in September, October and January. The results of Desai (2008) showed that the population of nymphs and started from 37th SMW, while damage on hills of rice brown plant hopper was initiated from 37th SMW. Peak stage of nymphs, adults and per cent damage was observed during 42nd SMW. The severity of the pest was seen at the reproductive stage of the crop. These results confirm the findings of present investigation under conventional planting method.

B. SRI method:

i. I year (*Kharif 2012*):

Under SRI method of planting, the rice brown plant hopper data presented in Table 4 and Fig. 4-5 has shown the fact that the hill damage (0.24%) and the population of nymphs and adults (0.32/hill) was initiated from first week of September (36th SMW). Further, the incidence and population was gradually increased and the peak stage of per cent hill damage (2.36%) and the population (2.36/hill) was reached during last week of September (39th SMW). Thereafter, the incidence declined and observed till harvest of the crop (43rd SMW).

ii. II year (*Kharif 2013*):

The rice brown plant hopper seasonal incidence results presented in Table 4 and Fig. 4-5 revealed that the hill damage (0.18%) and the population of nymphs and adults (0.25/hill) was started from first week of September (36th SMW). Thereafter, the hill damage and the population was found gradually increasing and the maximum per cent hill damage (2.47%) and the population (2.72/hill) was recorded during last week of September (39th SMW). Further, the incidence was declined till harvest of the crop (43rd SMW).

iii. Pooled:

The seasonal incidence and the population data of rice brown plant hopper under SRI method of planting is presented in Table 4 and Fig. 4-5 showed that the hill damage (0.21%) and the population of nymphs and adults (0.29/hill) was initiated from first week of September (36th SMW). Thereafter, the hill damage and the population was gradually increased and the peak stage of per cent hill damage (2.42%) and the population (2.54/hill) was observed during last week of September (39th SMW). The intensity of the pest damage was also seen at the reproductive stage of the crop in SRI method of planting. Later on, the incidence declined and found till harvest of the crop (43rd SMW).

However, the infestation level and the population of rice brown plant hopper under SRI method of planting was found comparatively less than conventional planting method.

4.1.1.4 Rice earhead bug (*Leptocorisa acuta* Stal.)

A. Conventional method (Transplanting):

i. I year (*Kharif* 2012):

The data of *Kharif* 2012 presented in Table 5 and Fig. 6 shown the fact that the population of nymphs and adults (1.60/5 net sweep) of rice earhead bug was commenced from first week of September (36th SMW). The gradual increase in population was observed and the peak stage of population (10.20/5 net sweep) was recorded during first week of October (40th SMW). Thereafter, the incidence declined and observed till harvest of the crop (43rd SMW).

ii. II year (*Kharif* 2013):

The second year data (Table 5 and Fig. 6) of rice earhead bug demonstrated that the population of nymphs and adults (1.85/5 net sweep) was started from first week of September (36th SMW), which showed increase in population after 36th SMW and the reached peak level of the population (9.85/5 net sweep) during first week of October (40th SMW). Further, the incidence declined and recorded population of

5.80/5 net sweep till harvest of the crop (43rd SMW) under conventional method of planting.

iii. Pooled:

Pooled data of rice earhead bug recorded in conventional method of planting (Table 5 and Fig. 6) revealed that the population of nymphs and adults (1.73/5 net sweep) was initiated from first week of September (36th SMW). The population of nymphs and adults showed increasing chart after 36th SMW and the peak stage of the population (10.03/5 net sweep) was reached during first week of October (40th SMW). The amount of severity of the pest was seen at the milky stage of the crop and continue till hardening of grains in conventional method of planting. Thereafter, the incidence started to decline and observed till harvest of the crop (43rd SMW) with population of 5.95/5 net sweep.

According to Butani and Jotwani (1976), Garg and Sethi (1980), Grist (1981) and Saroja and Raju (1985) the earhead bugs remained in the field till the grain hardening and the successive generations migrated from early maturing variety to late maturing varieties. Singh and Chandra (1967) reported peak population of earhead bug at late September or early October. While, Pathak (1968) reported the maximum population of the bugs during September and population declined from the end of October. Rai *et al.* (1990) recorded two major peaks of earhead bugs at 37th week (second week of September) and 40th week (First week of October).

In the study of Deore (2002), population dynamics of the earhead bug (nymphs and adults) activity was observed from middle of September to second week of November and it was at higher level in first week of November. While, Takeuchi *et al.* (2005) found that over wintered adults of *L. chinensis* appeared in grass fields on rice from late June to early July and their population fluctuation until October end. These reports of conventional planting methods are more or less tally with the present findings, but some differences might be due to change of locations and rice variety. The present findings is also match with the

results of Ghule (2006), who recorded the activity of earhead bug on rice from second week of September to first week of November with higher level in fourth week of October during *Kharif* as well as Pushpakumari and Tiwari (2005) noted the population of *L. acuta* in the first week of September just before flowering of the crop and the highest number was recorded in second week of October, which was at the milky stage of the crop.

Table 5: Seasonal incidence of rice earhead bug in Conventional and SRI Method during *Kharif* 2012 and 2013

Month	Std. Meteoro. Weeks	No. of nymphs and adults of earhead bug/5 net sweep					
		Conventional Method			SRI Method		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
JULY	28	0.00	0.00	0.00	0.00	0.00	0.00
	29	0.00	0.00	0.00	0.00	0.00	0.00
	30	0.00	0.00	0.00	0.00	0.00	0.00
	31	0.00	0.00	0.00	0.00	0.00	0.00
AUG.	32	0.00	0.00	0.00	0.00	0.00	0.00
	33	0.00	0.00	0.00	0.00	0.00	0.00
	34	0.00	0.00	0.00	0.00	0.00	0.00
	35	0.00	0.00	0.00	0.00	0.00	0.00
SEPT.	36	1.60	1.85	1.73	1.20	1.45	1.33
	37	4.00	3.65	3.83	2.80	2.70	2.75
	38	5.40	4.90	5.15	4.25	3.85	4.05
	39	6.15	6.45	6.30	5.10	5.60	5.35
OCT.	40	10.20	9.85	10.03	8.70	9.10	8.90
	41	9.25	8.10	8.68	7.60	7.30	7.45
	42	7.20	6.90	7.05	6.00	5.70	5.85
	43	6.10	5.80	5.95	4.75	4.90	4.83

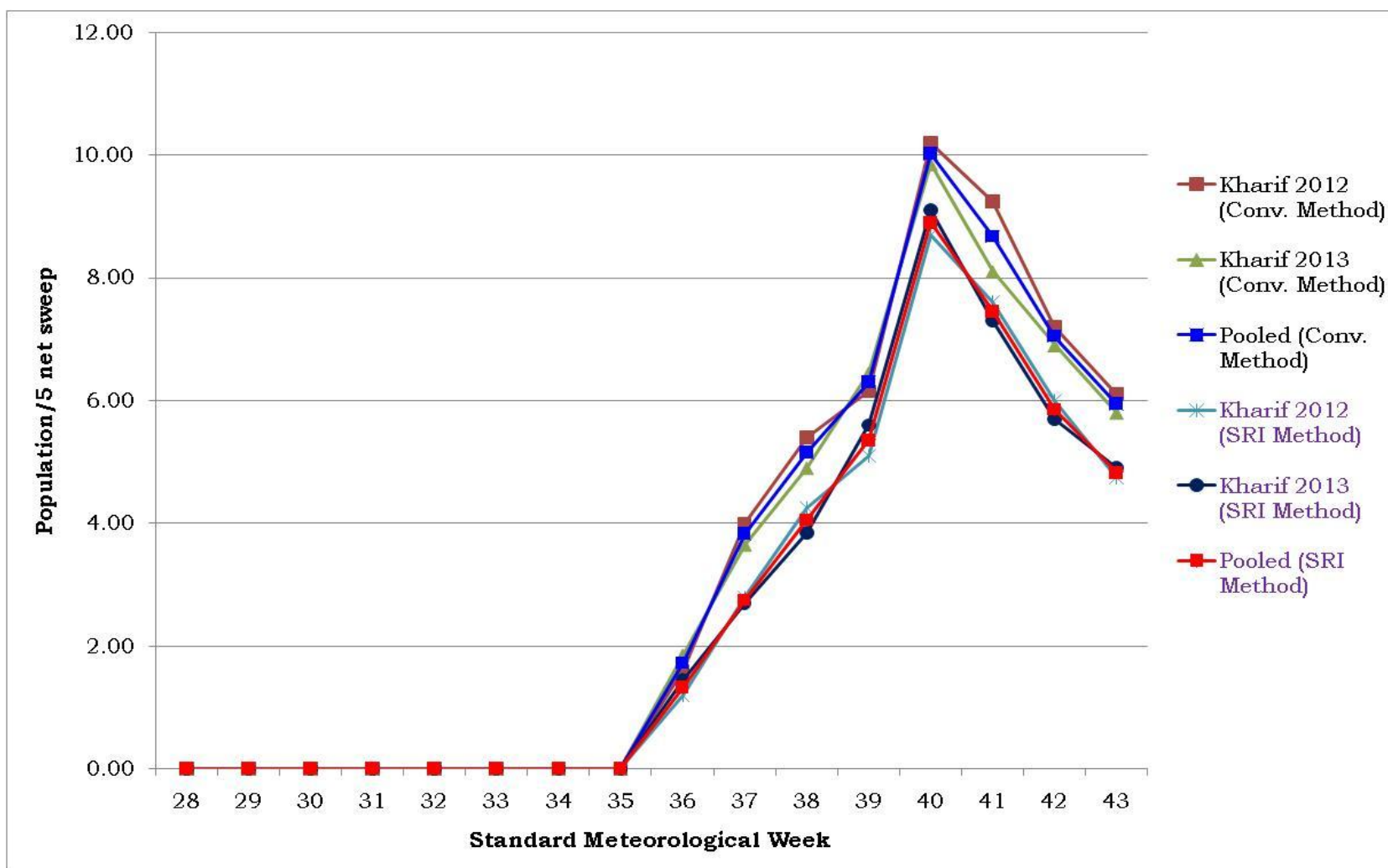


Fig. 6: Seasonal incidence of rice earhead bug in Conventional and SRI Method

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI method of planting, the rice earhead bug data of first year presented in Table 5 and Fig. 6 exhibited that the population of nymphs and adults (1.20/5 net sweep) was commenced from first week of September (36th SMW). Thereafter, the population was steadily increased and the peak stage of the population (8.70/5 net sweep) was reached during first week of October (40th SMW), which further established decline population and recorded till harvest of the crop (43rd SMW).

ii. II year (*Kharif* 2013):

The rice earhead bug seasonal incidence results of *Kharif* 2013 (Table 5 and Fig. 6) revealed that the population of nymphs and adults (1.45/5 net sweep) began from first week of September (36th SMW). Thereafter, the population was slowly increasing and the maximum population (9.10/5 net sweep) was recorded at first week of October (40th SMW) and then further showed declined infestation till harvest of the crop (4.90/5 net sweep).

iii. Pooled:

The seasonal incidence and the population data of rice earhead bug under SRI method of planting is presented in Table 5 and Fig. 6 showed that the population of nymphs and adults (1.33/5 net sweep) was initiated from first week of September (36th SMW). Thereafter, the population was gradually increased and the peak stage of the population (8.90/5 net sweep) was observed during first week of October (40th SMW). The intensity of the pest damage was also seen at the milky stage of the crop in SRI method of planting. Later on, the incidence started to decline and found till harvest of the crop (4.83/5 net sweep).

These population results of rice earhead bug under both the methods of rice cultivation showed that SRI method of planting was

found effective in lowering down the population of earhead bug as compared to than conventional planting method.

4.1.1.5 Rice leaf folder (*Cnaphalocrocis medinalis* Guenee)

A. Conventional method (Transplanting):

i. I year (*kharif* 2012):

The data presented in Table 6 and graphically depicted in Fig. 7 revealed that 0.57% damaged leaves of rice leaf folder, *C. medinalis* was initiated from third week of August (34th SMW) and reached to its peak level of 2.04% damaged leaves during fourth week of September (39th SMW). Then after, per cent damaged leaves (0.68) was gradually declined and reached to a zero level at the maturity of crop (43rd SMW) during *Kharif* 2012 in conventional method of planting.

ii. II year (*kharif* 2013):

The infestation of leaf folder in second year trial was recorded from third week of August (34th SMW) with 0.82% leaf damage in field, which showed increasing incidence and reach its peak during fourth week of September (39th SMW) with 2.56% leaf damage. The infestation of leaf folder showed decline an population after 39th SWM and attained zero level at harvest (Table 6 and Fig. 7). The incidence of the leaf folder was slightly higher during second year trial, which may be due to seasonal difference of both years.

iii. Pooled:

The data on seasonal occurrence of leaf folder, *C. medinalis* (Table 6 and Fig. 7) revealed that the pest first appeared on 3rd week of August (34th SMW) with 0.77% leaf damage, continued till 3rd week of October (42nd SMW), when crop was almost nearer to maturity stage. The activity of the pest gradually increased and reached to peak level during 4th week of September (39th SMW) when leaf damage due to leaf folder was 2.30% in conventional method of planting.

Earlier, Ram (1986) observed the population of *C. medinalis* peaked in October and Kushwaha (1988) reported that infestation of *C. medinalis* peaked during second week of September when crop was at the booting to panicle emergence stage. Velusamy and Subramaniam (1974) recorded *C. medinalis* occurrence throughout the year in Tamil Nadu and reaching peak numbers during October-November and April. According to Kaul and Singh (1999), peak activity of *C. medinalis* larvae occurred during second week of September at Kangra valley.

The leaf folder infestation at grain filling stage was more detrimental which was in accordance with the findings made by Saikia and Parameswaran (1999) as well as Mishra *et al.* (2001) who observed maximum leaf folder damage during maximum tillering stage of the crop. While, Patnaik (2001) pointed out increased infestation of leaf folder in rice that during the last week of September and first week of October and Kumar *et al.* (2003) recorded the peak activity of leaf folder in the first fortnight of August during the *Kharif* season. Alvi *et al.* (2003) also reported the activity of *C. medinalis* from second week of August to second week of October with peak activity during second fortnight of September in Pakistan. These results of above authors are more or less similar may be due to change in location research trial, but confirms the similar trend of the seasonal occurrence.

Similarly, Kharat (2006) found leaf folder incidence started increasing from 32nd standard week and declining from 42nd standard week. The incidence was found highest in 41st standard week, while Patel (2006) reported leaf folder incidence from 36th standard week and its peak level (3.20%) during 43rd standard week, which declined gradually and reached to a zero level at the maturity of crop. Sankpal (2011) showed that the higher incidence of *C. medinalis* was observed from 3rd week of September to 3rd week of October. Similarly, Boopathi (2012) showed that leaf folder was initiated on last week of August and reach peak population during third week of September, which decline in preceding weeks as well as Gole (2012) also confirmed the initiation of

leaf folder incidence from second week of August (32nd SMW). These reports are more or less similar and strongly support the present finding.

Table 6: Seasonal incidence of rice leaf folder in Conventional and SRI Method during *Kharif* 2012 and 2013

Month	Std. Meteorol. Weeks	% leaf damage by leaf folder					
		Conventional Method			SRI Method		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
JULY	28	0.00	0.00	0.00	0.00	0.00	0.00
	29	0.00	0.00	0.00	0.00	0.00	0.00
	30	0.00	0.00	0.00	0.00	0.00	0.00
	31	0.00	0.00	0.00	0.00	0.00	0.00
AUG.	32	0.00	0.00	0.00	0.00	0.00	0.00
	33	0.00	0.00	0.00	0.00	0.00	0.00
	34	0.57	0.82	0.70	0.59	0.80	0.70
	35	0.99	1.05	1.02	1.03	1.23	1.13
SEPT.	36	1.53	1.64	1.59	1.60	1.72	1.66
	37	1.70	1.90	1.80	1.87	1.90	1.89
	38	2.08	2.44	2.26	2.16	2.72	2.44
	39	2.04	2.56	2.30	2.46	2.86	2.66
OCT.	40	1.93	2.22	2.08	2.34	2.36	2.35
	41	1.39	1.86	1.63	1.59	1.42	1.51
	42	0.68	0.80	0.74	0.62	0.58	0.60
	43	0.00	0.00	0.00	0.00	0.00	0.00

B. SRI method:

i. I year (*kharif* 2012):

The results of first year seasonal incidence of leaf folder under SRI method of planting presented in Table 6 and graphically depicted in Fig. 7 showed that per cent damaged leaves of 0.59 of rice leaf folder initiated from 3rd week of August (34th SMW) and reached to its peak damage of 2.34% during 4th week of September (39th SMW). Thereafter, per cent damaged leaves (0.62) was gradually declined and reached to a zero level at the maturity of crop (43rd SMW).

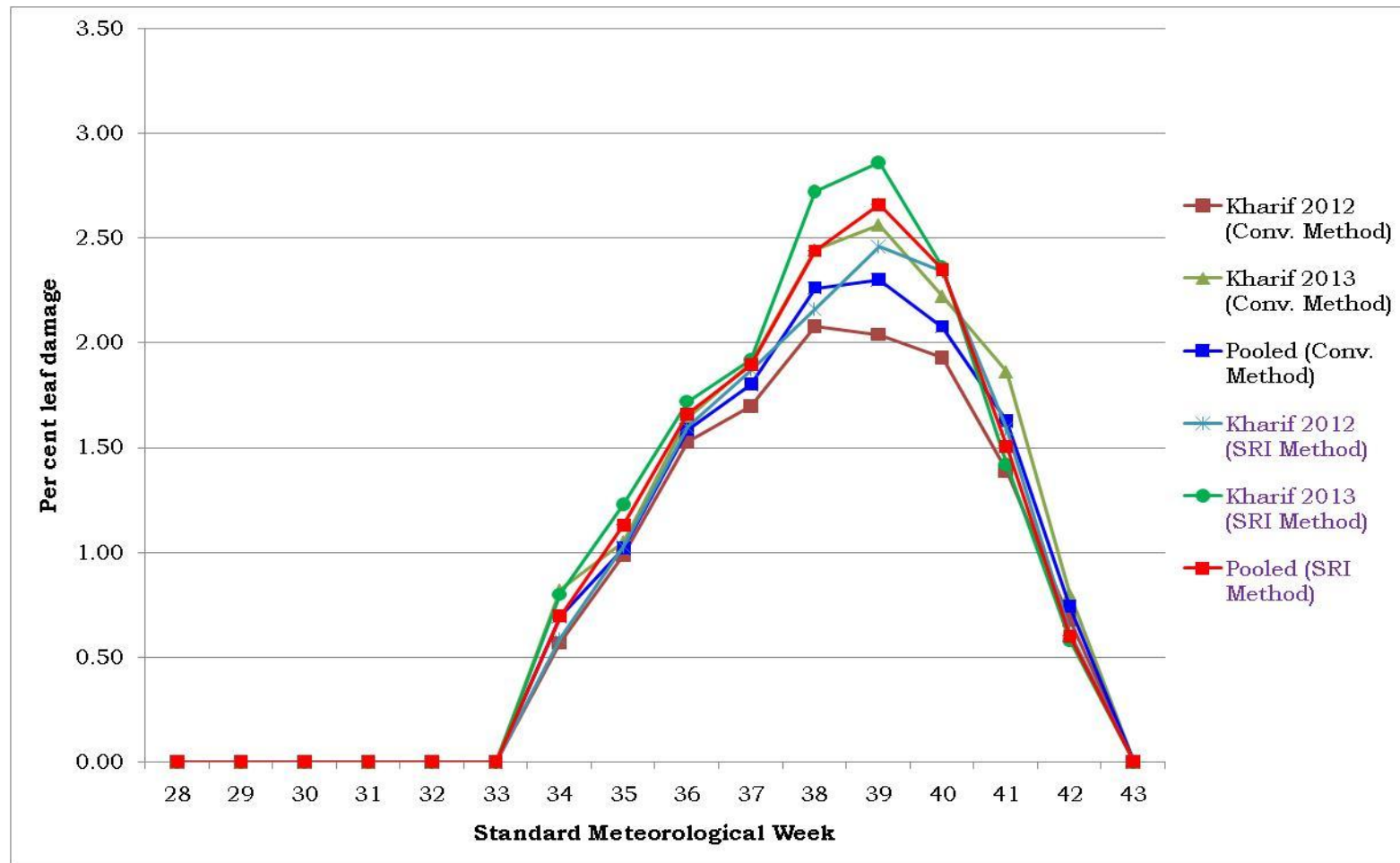


Fig. 7: Seasonal incidence of rice leaf folder in Conventional and SRI Method



Plate No. 13: Adult of rice leaf folder (*C. medinalis*)



Plate No. 14: Leaf folder (*C. medinalis*) damaged leaves in rice field

ii. II year (*Kharif* 2013):

The data on incidence of per cent damaged leaves of rice leaf folder during *Kharif* 2013 was also started from 34th SMW (0.80%) and reached to its peak damage during 39th SMW (2.66%), which showed further gradual decline in per cent damaged leaves (2.35) and reached to zero level at 43rd SMW (Table 6 and Fig. 7). The damage intensity of the leaf folder was slightly higher during *kharif* 2013 as compared to *kharif* 2012.

iii. Pooled:

The pooled data on seasonal incidence of leaf folder, *C. medinalis* in SRI method presented in Table 6 and graphically depicted in Fig. 7 revealed that 0.70% damaged leaves of rice leaf folder was initiated from 3rd week of August (34th SMW), which increased further and reached to its peak damage of 2.66% during 4th week of September (39th SMW). Then after, percentage of damaged leaves (2.35) was gradually declined and reached to zero level at the maturity of crop (43rd SMW).

The difference in leaf damage under different planting methods showed that the higher damage of leaf folder, *C. medinalis* was observed in SRI method than conventional method (transplanting) of planting indicating less efficiency of SRI method to reduce the leaf folder infestation.

In earlier reports of Anonymous (2010^b), standard transplanting (STP) proved most effective planting method against *C. medinalis* in South India, while SRI was found less effective for controlling the insect pests. Similar type of trend was also observed in this study. Likewise, Gole (2012) recorded the lowest per cent leaf damage due to leaf folder in Standard Transplanting Method (STP) (2.39%) as compared to SRI (3.69%) and found significantly superior than rest of the treatments. Thus, the observations in case of STP are in accordance with this present report.

4.1.1.6 Rice blue beetle (*Leptispa pygmaea* Baly)

A. Conventional method (Transplanting):

i. I year (*Kharif* 2012):

The results of *Kharif* 2012 on seasonal incidence of blue beetle (Table 7 and Fig. 8-9) illustrated that the leaf damage (0.62%) and the population of adults (0.92/plant) of blue beetle was initiated from last week of July (31st SMW). In advance stage, the gradual increase in infestation and population was recorded, which reached peak stage during last week of August (35th SMW) and showed per cent leaf damage of 2.80% with population of 2.38 adults/plant. Later on, the incidence started declining and observed up to end of September (39th SMW).

ii. II year (*Kharif* 2013):

During *Kharif* 2013 (Table 7 and Fig. 8-9), rice blue beetle leaf damage (0.72%) and the population build up of adults (0.84/plant) initiated from last week of July (31st SMW). The increase in infestation and population was recorded after 31st SMW and attained maximum level of leaf damage (2.88%) during third week of August (34th SMW), while the population (2.44 adults/plant) was found during last week of August (35th SMW). Thereafter, the incidence started declining and observed up to end of September (39th SMW).

iii. Pooled:

Rice blue beetle pooled data recorded in conventional method of planting is presented in Table 7 and Fig. 8-9 has shown the fact that the leaf damage (0.67%) and the population of adults (0.88/plant) was initiated from last week of July (31st SMW). This infestation and population of adult showed increasing graph after 31st SMW and the peak stage of per cent leaf damage (2.75%) and the population (2.41 adults/plant) was reached at last week of August (35th SMW). The intensity of incidence of the pest was seen at the initial vegetative stage of the crop in conventional method of planting and then the incidence started declining and found till last week of September (39th SMW).

Table 7: Seasonal incidence of rice blue beetle in Conventional and SRI Method during *Kharif* 2012 and 2013

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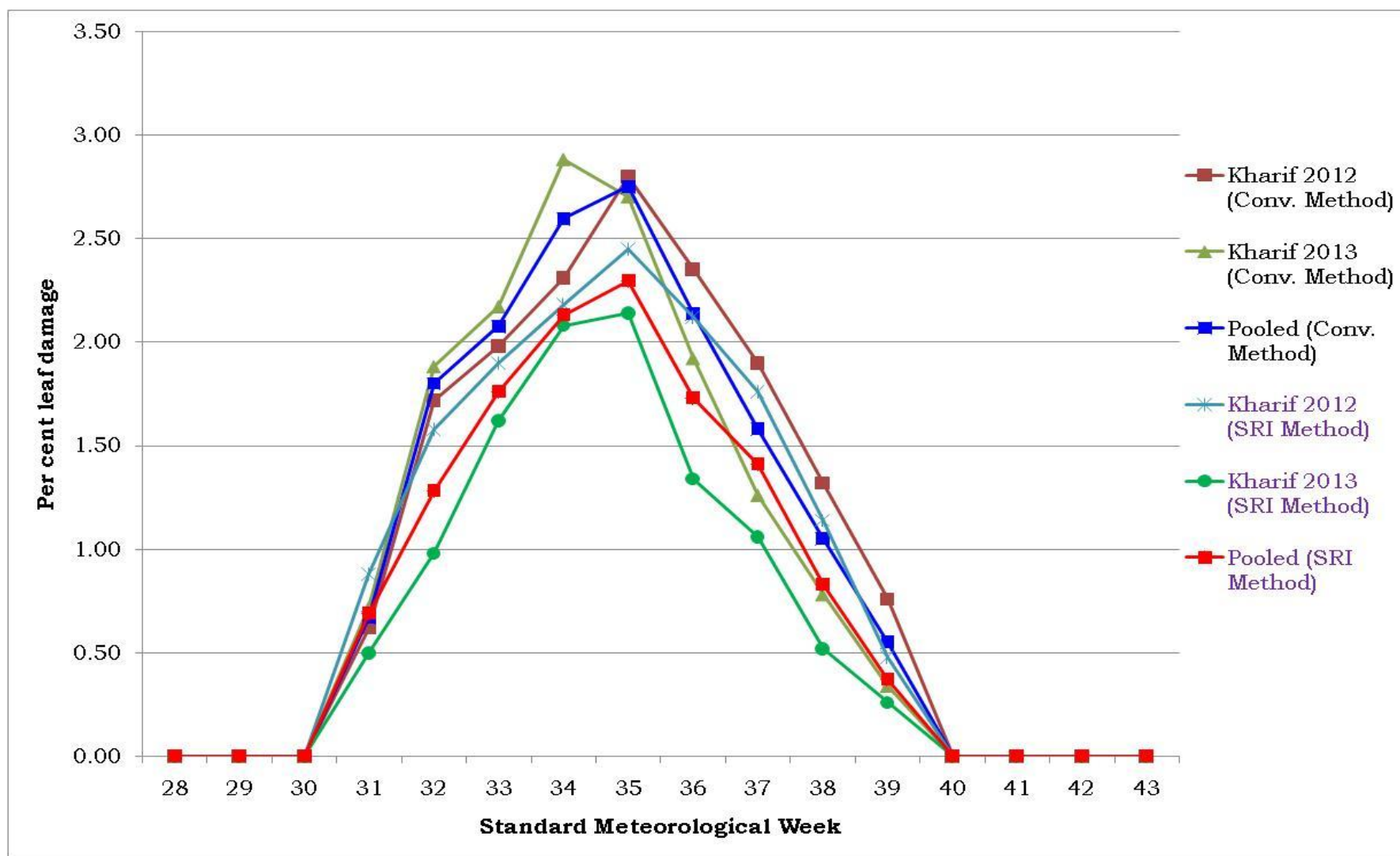


Fig. 8: Seasonal incidence (% leaf damage) of rice blue beetle in Conventional and SRI Method

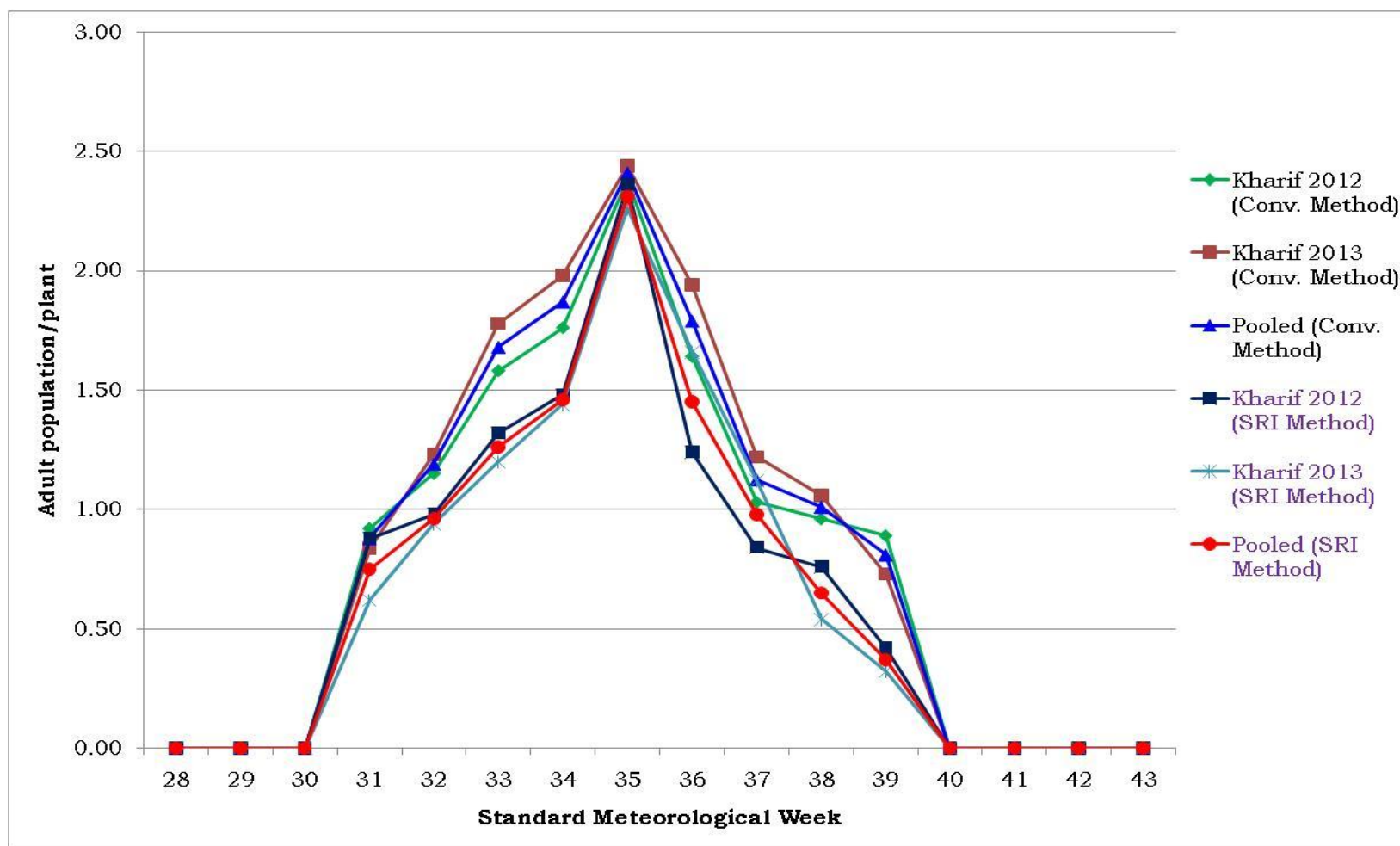


Fig. 9: Seasonal incidence (adults/plant) of rice blue beetle in Conventional and SRI Method



Plate No. 15: Grub and Adult of rice blue beetle (*L. pygmaea*)



Plate No. 16: Rice blue beetle (*L. pygmaea*) damaged leaves

In earlier findings, Patel (1977) noted the highest pest population of rice blue beetle in the month of August and September during *Kharif* season. While, Dalvi *et al.* (1985) reported initiation of the blue beetle incidence in the field during the second fortnight of July. They also pointed out that the month of August and September were generally more congenial for rapid build-up of the pest. These findings confirms the present investigation results.

Another finding which confirms the present study is noted in the following results. The infestation of rice blue beetle was recorded during 35th to 38th standard week in *Kharif* 2001 at Navsari (Anonymous, 2002^b). Similarly, pest caused 0.28% infestation during the 33rd to 36th standard week in *Kharif* at Navsari (Anonymous, 2006^{a & b}) as well as the average infestation of was 0.10% during *Kharif* 2002 (Anonymous, 2003^{a & b}). Likewise, the incidence was 0.17% during 33rd to 36th standard week of *Kharif* at NARP, Navsari (Anonymous, 2007^{a & b}). The findings of Patel (2008) showed that population of rice blue beetle (1.08 beetle/plant) and per cent damaged leaves (1.03%) was initiated from 31st standard week and reached to its peak level (3.01 beetle/plant and 3.93% damaged leaves) during 34th standard week of *kharif* 2007 at Navsari as well as Kharat (2006) observed the incidence increased from 32nd standard week and started declining from 42nd standard week. These data on incidence and population of blue beetle data strongly confirms the present investigation results.

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI method of planting, the rice blue beetle data of first year presented in Table 7 and Fig. 8-9 illustrated the fact that the leaf damage (0.88%) and the population of adults (0.88/plant) was initiated from last week of July (31st SMW). In advance week, the incidence and population were gradually increase and the peak stage of per cent leaf damage (2.45%) and the population (2.36 adults/plant) was reached during last week of August (35th SMW). Thereafter, the incidence starts

decline and at end of September (39th SMW) recorded leaf damage of 0.48% and the population of 0.42 adults/plant.

ii. II year (*Kharif* 2013):

The rice blue beetle seasonal incidence of second year results (in Table 7 and Fig. 8-9) revealed that the leaf damage (0.50%) and the population of adults (0.62/plant) was started from last week of July (31st SMW). Thereafter, the leaf damage and the population were showed gradually increasing trend and the maximum per cent leaf damage (2.14%) and the population (2.26 adults/plant) was recorded during last week of August (35th SMW). Further, the incidence showed declined infestation at the end of September (39th SMW).

iii. Pooled:

The pooled seasonal incidence and the population data of rice blue beetle under SRI method of planting is illustrated in Table 7 and Fig. 8-9 revealed that the leaf damage (0.69%) and the population of adults (0.75/plant) was initiated from last week of July (31st SMW). In progressive week, the incidence was gradually increased and the peak stage of per cent leaf damage (2.30%) and population (2.31 adults/plant) was reached at last week of August (35th SMW). This intensity of the pest damage was seen during early vegetative stage of the crop in SRI method of planting. Later on, the incidence declined and ended at 39th SMW with 0.37% leaf damage and the population of 0.37 adults/plant).

However, SRI method of planting showed less infestation level and the population of rice blue beetle than conventional planting method.

4.1.1.7 Rice sheath mite (*Steneotarsonemus spinki* Smiley)

A. Conventional method (Transplanting):

i. I year (*Kharif* 2012):

During *Kharif* 2012, the number egg and active stages of mites recorded ranged from 1.80 to 20.76 per leaf sheath in conventional method of planting (Table 8 and Fig. 10). The mite incidence first

appeared in 36th SMW *i.e.* during the first week of September. It was gradually increased and reached its peak (20.76/leaf sheath) during the first week of October (40th SMW). It was declined in the second week of October and recorded till harvest of the crop (43rd SMW).

ii. II year (*Kharif* 2013):

Similar trend of mite population was observed during *Kharif* 2013 under conventional planting method (Table 8 and Fig. 10). However, population was comparatively higher than the previous year and it ranged from 1.65 to 19.25/leaf sheath. During 2013, the incidence was initiated one week earlier than previous year *i.e.* from last week of September *i.e.* 35th SMW (1.65/leaf sheath) and attained peak of 19.25/leaf sheath during last week of September (39th SMW). Further, the population started declining and recorded (9.58/leaf sheath) till harvest of the crop (43rd SMW).

iii. Pooled:

The pooled results of number of egg and active stages of mite under conventional planting method are depicted in Table 8 and Fig. 10. The number of mites recorded ranged from 0.80 to 18.04/leaf sheath. The mite incidence was first appeared during the first week of September (35th SMW) with 0.80 mites/leaf sheath. Then after, mite population was gradually increased and reached its peak (18.04/leaf sheath) during the first week of October (40th SMW). It was declined in the second week of October and recorded (9.70/leaf sheath) till harvest of the crop (43rd SMW).

Bandhanja (2005) reported that the peak incidence of mite on rice crop was started from 36th SMW (September first week) and there was a gradual increase in population and reached its peak during 43rd SMW (October last week) during both the seasons during *Kharif* 2002 and 2003, which confirms the present experimental results on mite population.

Table 8: Seasonal incidence of rice sheath mite in Conventional and SRI Method during *Kharif* 2012 and 2013

Month	Std. Meteorol. Weeks	Mean number of mobile stages of mite per leaf sheath					
		Conventional Method			SRI Method		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
JULY	28	0.00	0.00	0.00	0.00	0.00	0.00
	29	0.00	0.00	0.00	0.00	0.00	0.00
	30	0.00	0.00	0.00	0.00	0.00	0.00
	31	0.00	0.00	0.00	0.00	0.00	0.00
AUG.	32	0.00	0.00	0.00	0.00	0.00	0.00
	33	0.00	0.00	0.00	0.00	0.00	0.00
	34	0.00	0.00	0.00	0.00	0.00	0.00
	35	0.00	1.65	0.83	0.00	1.55	0.78
SEPT.	36	1.80	2.42	2.11	1.92	2.08	2.00
	37	3.14	4.76	3.95	2.96	3.34	3.15
	38	7.20	10.66	8.93	4.94	7.18	6.06
	39	12.62	19.25	15.94	9.02	11.66	10.34
OCT.	40	20.76	15.32	18.04	13.84	10.05	11.95
	41	15.20	11.12	13.16	12.78	9.30	11.04
	42	13.30	10.86	12.08	10.50	5.89	8.20
	43	9.82	9.58	9.70	6.92	7.26	7.09

B. SRI method:**i. 1 year (*Kharif* 2012):**

The number of egg and active stages of mites recorded during *Kharif* 2012 ranged from 1.92 to 13.84/leaf sheath in SRI method of planting (Table 8 and Fig. 10). The mite incidence first appeared from the first week of September (36th SMW). It was gradually increased and reached its peak (13.84/leaf sheath) during the first week of October (40th SMW). It was started to decline in the second week of October and recorded till harvest of the crop (43rd SMW).

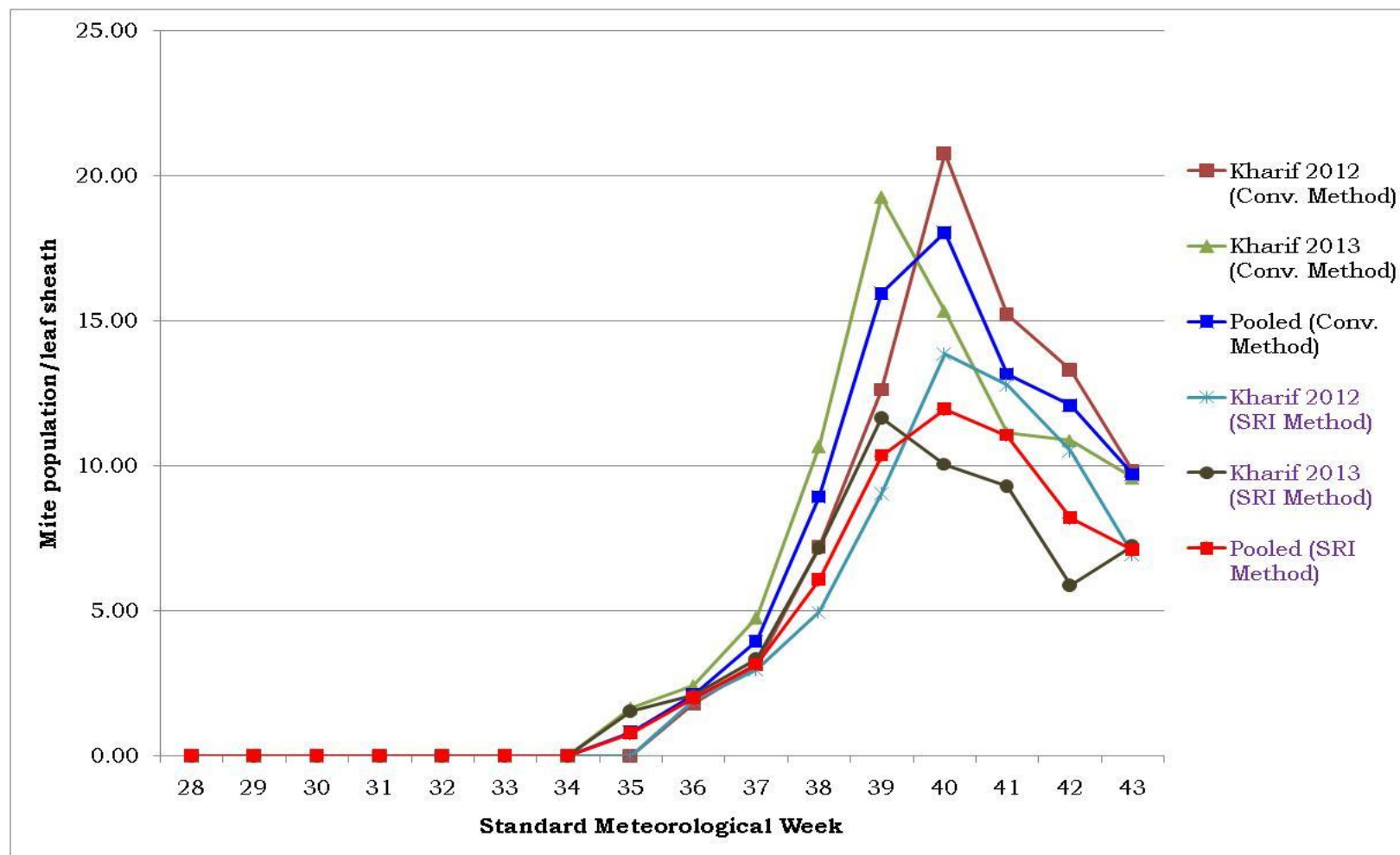


Fig. 10: Seasonal incidence of rice sheath mite in Conventional and SRI Method



Plate No. 17: Affected stem due to rice sheath mite (*S. spinkii*)

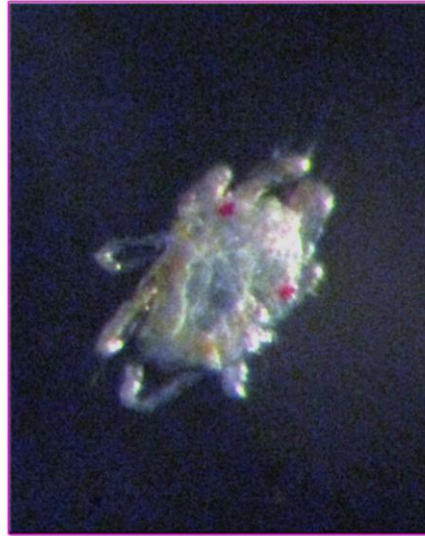


Plate No. 18: Adult stage of rice sheath mite (*S. spinkii*)



Plate No. 19: Sheath mite (*S. spinkii*) counting method from affected leaf of different varieties

ii. II year (*Kharif* 2013):

During *Kharif* 2013, the population of mite was comparatively lower than the previous year and it ranged from 1.55 to 11.66/leaf sheath under SRI method (Table 8 and Fig. 10). The incidence initiated earlier i.e. from last week of September (35th SMW) (1.55/leaf sheath) as compared to previous year incidence and attained peak of 11.66/ leaf sheath during last week of September (39th SMW). Further, the population declined and recorded till harvest of the crop (43rd SMW).

iii. Pooled:

The pooled results of mite incidence under SRI planting method are depicted in Table 8 and Fig. 10. The number of mites recorded ranged from 0.78 to 11.95/leaf sheath. The mite incidence was started from the first week of September (35th SMW) with 0.78 mites/leaf sheath. Further, it was gradually increased and reached its peak (11.95/leaf sheath) during the first week of October (40th SMW). Then, it was declined in the second week of October and recorded till harvest of the crop (43rd SMW).

Thus, mite incidence was started from the booting stage of the crop, increased gradually and reached to peak during dough and milky stage of the crop under both the method of planting i.e. conventional and SRI. The SRI method showed lower mite population as compare to conventional method of planting.

4.1.1.8 Bio-Agents:

4.1.1.8.1 Spiders:

A. Conventional method (Transplanting):

i. I year (*Kharif* 2012):

The data on population abundance of spiders (Table 9 and Fig. 11) indicated that the spider activity (0.47/hill) started on 4th week of July (31st SMW) and it continued till 4th week of October in conventional method of planting. The spider population was in between 0.47 to

4.24/hill during cropping season. The peak (4.24/hill) population of spiders was reached during 1st week of October (40th SMW). Thereafter, spider population gradually decreased (4.24 to 2.63/hill) from 2nd week of October to 4th week of October (43rd SMW).

ii. II year (*Kharif* 2013):

The population occurrence of spider in second year was recorded from 4th week of July (34th SMW) with 0.52 spider/hill in field, which showed increasing population (4.47/hill) and reached its peak during 1st week of October (40th SMW) (Table 9 and Fig. 11). The spider population was ranged between 0.52 to 4.47/hill during cropping season. The spider population showed declining trend after 40th SMW and observed till harvest of the crop. The population occurrence of spider was slightly higher during second year trial, which may be due to seasonal difference of both years.

iii. Pooled:

The pooled data of spiders population abundance (Table 9 and Fig. 11) indicated that the spider activity (0.50/hill) initiated from 4th week of July (31st SMW) and it continued till 4th week of October in conventional method of planting. The population range of spider was found between 0.50 to 4.36/hill during cropping season. The peak (4.36/hill) population of spiders was attained during 1st week of October (40th SMW). Thereafter, spider population gradually decreased (4.36 to 2.53/hill) from 2nd week of October till harvest (43rd SMW).

Similar results were obtained by Barrion and Litsinger (1995) from Phillipines, Anbalagan and Narayanasamy (1999) from Tamil Nadu, Khan and Mishra (2003) from Uttar Pradesh and Vijaykumar and Patil (2004) from Karnataka, wherein they found that the spider population was directly related to growth stages of the rice plants.

In the findings of Kharat (2006) it was revealed that the population of spiders increased from 32nd standard week and it was maximum in 40th standard week and Desai (2008) found that the population of spider

(0.35/hill) initiated from 29th SMW and reached to its peak level (2.22/hill) during 34th standard week in *Kharif* 2007. While, Patel (2008) showed that the population of spider was initiated from 29th standard week and reached to its peak level during 34th standard week of *Kharif* at Navsari. These results were match with the present findings. Whereas the present results are comparable with the observations of Kumar *et al.* (2008) who recorded the maximum population of spiders in the 2nd week of August, followed by the 3rd week, while the lowest population of spiders was observed in the 3rd week of October, followed by the 2nd week of the same month.

Table 9: Seasonal incidence of spider in Conventional and SRI Method during *Kharif* 2012 and 2013

Month	Std. Meteoro. Weeks	Population of spiders/hill					
		Conventional Method			SRI Method		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
JULY	28	0.00	0.00	0.00	0.00	0.00	0.00
	29	0.00	0.00	0.00	0.00	0.00	0.00
	30	0.00	0.00	0.00	0.00	0.00	0.00
	31	0.47	0.52	0.50	0.57	0.87	0.72
AUG.	32	0.68	0.74	0.71	0.77	0.98	0.88
	33	0.94	1.06	1.00	1.07	1.25	1.16
	34	1.56	1.76	1.66	1.67	1.91	1.79
	35	1.81	2.02	1.92	1.93	2.21	2.07
SEPT.	36	2.64	2.65	2.65	2.73	3.06	2.90
	37	3.38	3.44	3.41	3.49	3.92	3.71
	38	3.49	3.82	3.66	3.61	4.16	3.89
	39	3.72	4.12	3.92	3.87	4.96	4.42
OCT.	40	4.24	4.47	4.36	4.44	4.64	4.54
	41	4.09	3.05	3.57	4.21	3.37	3.79
	42	2.78	2.54	2.66	2.83	3.14	2.99
	43	2.63	2.42	2.53	2.68	2.71	2.70

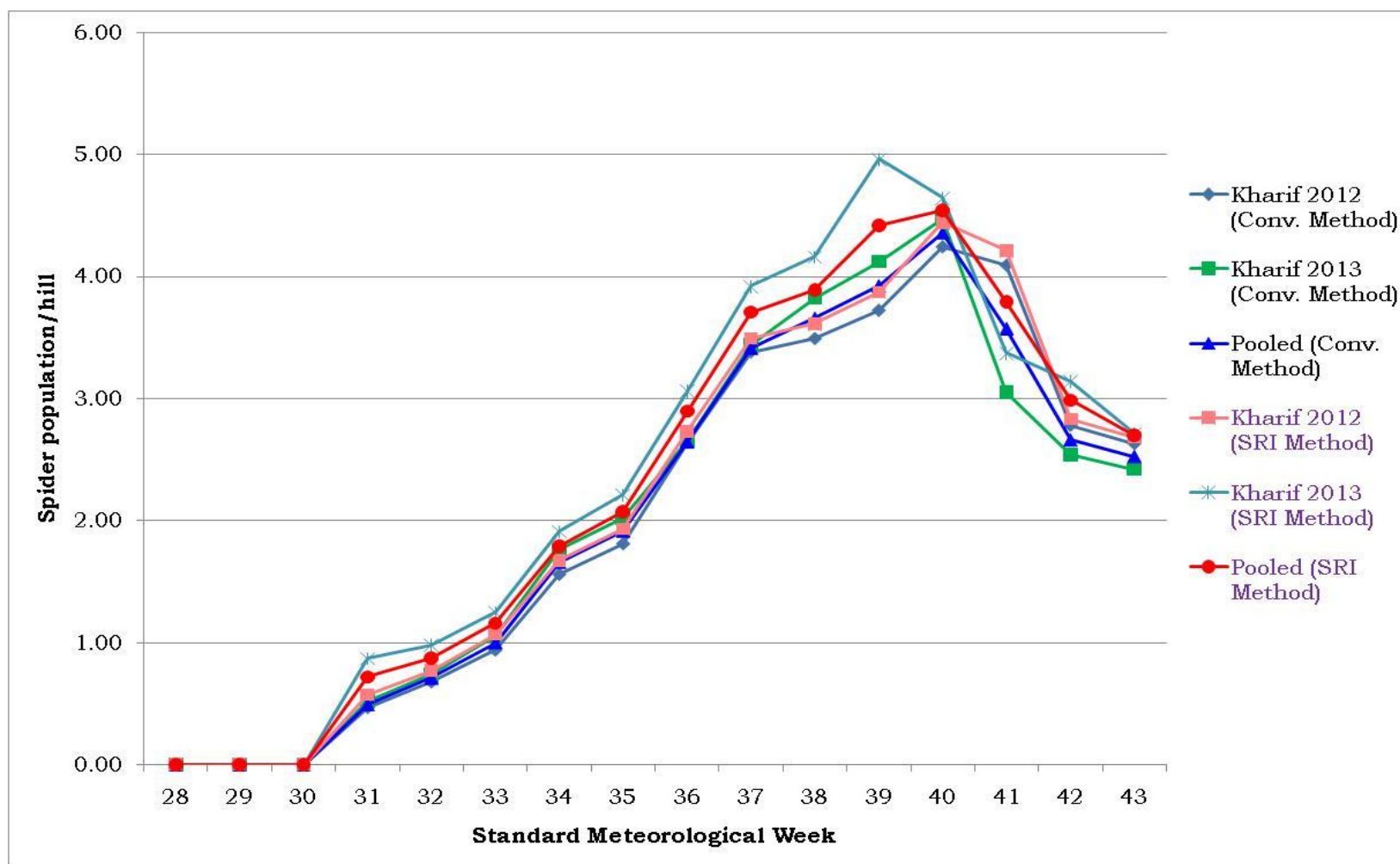


Fig. 11: Seasonal incidence of spider in Conventional and SRI Method

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI method of planting, the population occurrence of spiders (Table 9 and Fig. 11) showed that the spider movement (0.57/hill) also started on 4th week of July (31st SMW) and it continued till the harvest of the crop (43rd SMW). The spider population activity was seen between 0.57 to 4.44/hill during *Kharif* 2012. The highest population of spiders (4.44/hill) was reached during 1st week of October (40th SMW) and thereafter, the population gradually decreased from 2nd week of October to 4th week of October (2.68/hill).

ii) II year (*Kharif* 2013):

During second year (Table 9 and Fig. 11), the spider population was also recorded from 4th week of July (0.87/hill) in field, which showed increasing population and reached its peak (4.96/hill) during 4th week of September (39th SMW). The spider population decline then after and observed till harvest of the crop. The spider population occurrence was slightly higher during second year trial (*Kharif* 2013) as compare to first year data.

iii. Pooled:

The pooled data of spiders population in SRI planting (Table 9 and Fig. 11) revealed that the spider activity (0.72/hill) was commenced from 4th week of July (31st SMW) and it continued till the harvest of the crop. The spider population ranged between 0.72 to 4.54/hill during cropping season. The peak population of spiders (4.54/hill) was arrived during 1st week of October (40th SMW). Thereafter, spider population gradually declined from 2nd week of October till 4th week of October (43rd SMW). The population activity of spider was observed higher under SRI method of planting as compare to conventional method. These may be due to the difference in plant population.

4.1.1.8.2 Parasitoids:

I. Egg parasitoid:

A. Conventional method (Transplanting):

i. I year (*Kharif* 2012):

The study on the natural parasitism (Table 10 and Fig. 12) indicated that the egg masses of yellow stem borer were found to be predominantly parasitized by the Eulophid, *Tetrastichus schoenobii* in the plot of conventional planting. The egg parasitoid activity was observed between 33rd to 40th SMW. The egg parasitism by *T. schoenobii* was ranged from 12.50 to 33.33% with overall average of 14.34% during *Kharif* 2012. However, the peak activity of parasitoid species to the tune of 33.33% was occurred in first week of September (36th SMW) in conventional method.

ii. II year (*Kharif* 2013):

During second year (*Kharif* 2013), the same parasitoid, *T. schoenobii* was recorded on the egg masses of yellow stem borer (Table 10 and Fig. 12). The egg parasitoid activity was found between 34th to 41st SMW. The egg parasitism by *T. schoenobii* was recorded between 16.67 to 37.50% with overall average of 16.78%, where the peak activity of parasitoid was found during second week of September (37th SMW). The percentage of *T. schoenobii* parasitism was slightly higher during second year trial.

iii. Pooled:

The pooled results of two years (Table 10 and Fig. 12) showed that the egg parasitism by *T. schoenobii* was ranged between 12.50 to 33.04% with overall average of 15.56%. The egg parasitoid activity was observed between 33rd to 41st SMW. The peak parasitism by *T. schoenobii* was notices up to 33.04% during second week of September (37th SMW) under pooled data.

Table 10: Extent of parasitization of yellow stem borer egg masses in Conventional method (*Kharif* 2012 and 2013)

Month	Std. Meteo. Weeks	No. of egg masses collected			Number of egg masses parasitized			Per cent parasitism by <i>T. schoenobii</i>		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
AUG.	32	0	0	0	0	0	0	0.00	0.00	0.00
	33	4	3	3.5	1	0	0.5	25.00	0.00	12.50
	34	6	6	6	1	1	1	16.67	16.67	16.67
	35	8	7	7.5	1	2	1.5	12.50	28.57	20.54
SEPT.	36	6	6	6	2	1	1.5	33.33	16.67	25.00
	37	7	8	7.5	2	3	2.5	28.57	37.50	33.04
	38	8	9	8.5	2	3	2.5	25.00	33.33	29.17
	39	7	7	7	1	2	1.5	14.29	28.57	21.43
OCT.	40	6	5	5.5	1	1	1	16.67	20.00	18.33
	41	3	5	4	0	1	0.5	0.00	20.00	10.00
	42	0	0	0	0	0	0	0.00	0.00	0.00
	43	0	0	0	0	0	0	0.00	0.00	0.00
Average =		4.58	4.67	4.63	0.92	1.17	1.04	14.34	16.78	15.56

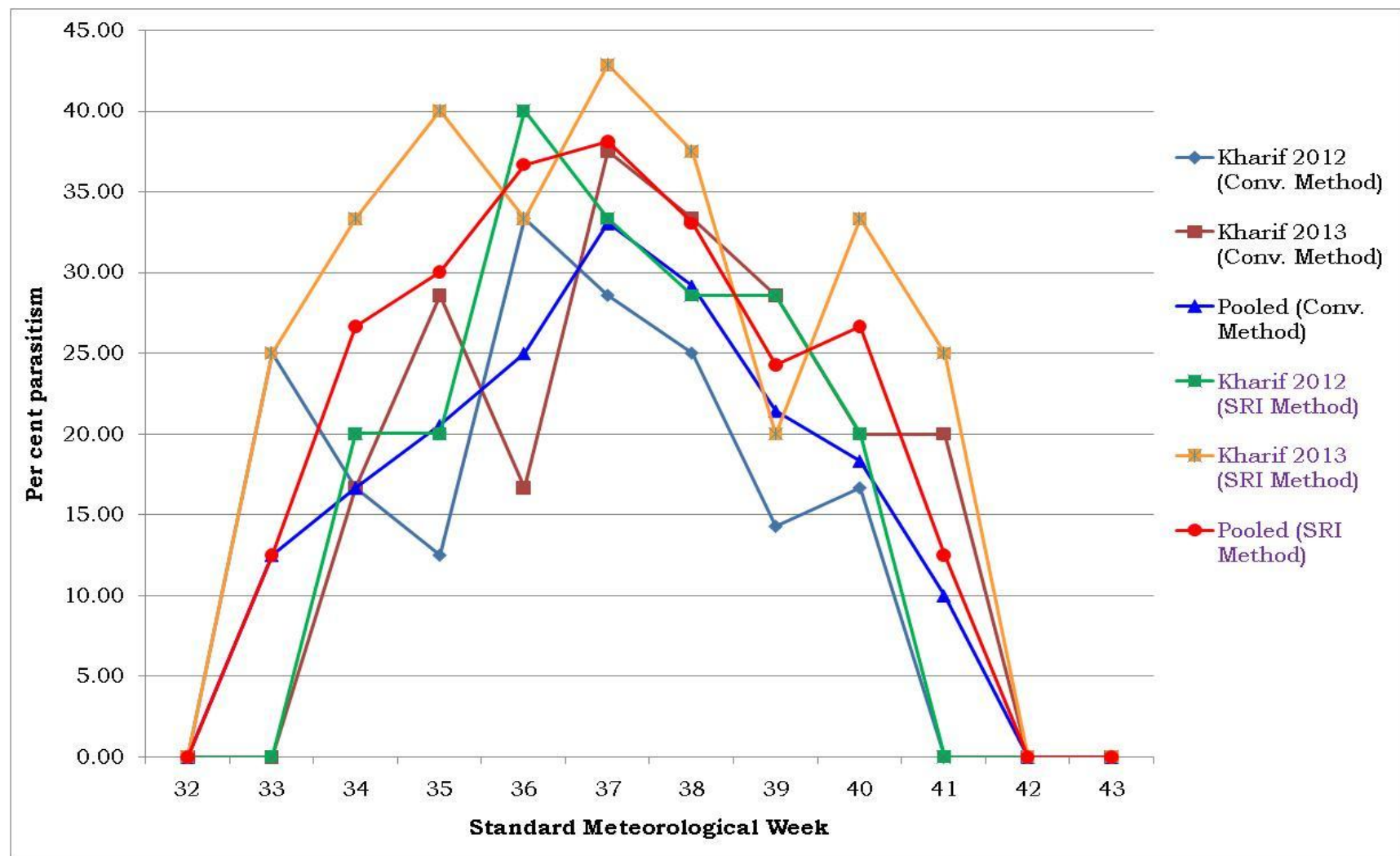


Fig. 12: Extent of parasitization of yellow stem borer egg masses in Conventional and SRI method



Plate No. 20: Egg masses collection of rice yellow stem borer (*S. incertulas*)



Plate No. 21: Rearing of egg parasitoid (*Tetrastichus schoenobii*) of rice yellow stem borer (*S. incertulas*)

The parasitization data of earlier scientists like Chandramohan and Chelliah (1990) recorded *T. schoenobii* as predominant egg parasitoids on yellow stem borer, *S. incertulas*, while Manju *et al.* (2002) showed that the egg masses parasitism due to *T. schoenobii* were more numerous at panicle initiation stage than at tillering stage and flowering stages and therefore the parasitism was higher at panicle initiation stage (45%) than at flowering (29.86%) and tillering (21.23%) stage. Similarly, Kumar *et al.* (2008) recorded the egg parasitoids had greater impact on the suppression of *S. incertulas*) and the most important egg parasitoids observed were *Telenomus* sp. and *Tetrastichus schoenobii* parasitizing up to 78.4 and 95.8 of October (95.8%), followed by the 3rd week (90.9%), while the lowest egg parasitization was found in the 1st week of August (6.4%), followed by the 2nd week. These results are more or less similar with the present parasitization findings.

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI method of planting, the results of the natural parasitism presented in Table 11 and Fig. 12 indicated that the egg masses of yellow stem borer were found to be predominantly parasitized by *T. schoenobii*. The egg parasitoid activity was observed between 34th to 40th SMW. The egg parasitism by *T. schoenobii* was ranged from 20.00 to 40.00% with overall average of 15.87% during *Kharif* 2012. However, the peak activity of parasitoid species was occurred in 36th SMW.

ii. II year (*Kharif* 2013):

The same egg parasitoid, *T. schoenobii* was also recorded during *Kharif* 2013 on the egg masses of yellow stem borer (Table 11 and Fig. 12). The egg parasitoid activity was found between 33rd to 41st SMW. The egg parasitism by *T. schoenobii* was ranged from 20.00 to 42.86% with overall average of 24.20%, where the peak activity of parasitoid was found during second week of September (37th SMW). The percentage of parasitism was slightly higher than first year results.

Table 11: Extent of parasitization of yellow stem borer egg masses in SRI method (*Kharif* 2012 and 2013)

Month	Std. Meteo. Weeks	No. of egg masses collected			Number of egg masses parasitized			Per cent parasitism by <i>T. schoenobii</i>		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
AUG.	32	0	0	0	0	0	0	0.00	0.00	0.00
	33	3	4	3.5	0	1	0.5	0.00	25.00	12.50
	34	5	6	5.5	1	2	1.5	20.00	33.33	26.67
	35	5	5	5	1	2	1.5	20.00	40.00	30.00
SEPT.	36	5	6	5.5	2	2	2	40.00	33.33	36.67
	37	6	7	6.5	2	3	2.5	33.33	42.86	38.10
	38	7	8	7.5	2	3	2.5	28.57	37.50	33.04
	39	7	5	6	2	1	1.5	28.57	20.00	24.29
OCT.	40	5	6	5.5	1	2	1.5	20.00	33.33	26.67
	41	3	4	3.5	0	1	0.5	0.00	25.00	12.50
	42	0	0	0	0	0	0	0.00	0.00	0.00
	43	0	0	0	0	0	0	0.00	0.00	0.00
Average =		3.83	4.25	4.04	0.92	1.42	1.17	15.87	24.20	20.03

iii. Pooled:

The pooled results of two years under SRI method (Table 11 and Fig. 12) revealed that the egg parasitism by *T. schoenobii* was ranged between 12.50 to 38.10% with overall average of 20.03%. The egg parasitoid activity was recorded between 33rd to 41st SMW. The peak parasitism by parasitoid was noticed during second week of September (37th SMW). The activity of egg parasitoid was found better in SRI method as compare to conventional method.

II. Larval parasitoid:

1. Rice yellow stem borer (*S. incertulas*):

A. Conventional method (Transplanting):

i. I year (*Kharif 2012*):

The data on the natural parasitism of yellow stem borer larvae under conventional planting (Table 12 and Fig. 13) indicated that the larvae were parasitized by the Braconid, *Apanteles* sp. The larval parasitoid activity was found between 34th to 41st SMW. The larval parasitism by *Apanteles* sp. was ranged from 9.09 to 20.00% with overall average of 9.68% during *Kharif 2012*. However, the peak activity of parasitoid species was occurred in first week (36th SMW) (20.00%) and fourth week of September (39th SWM) (16.67%).

ii. II year (*Kharif 2013*):

During second year (*Kharif 2013*), the same parasitoid, *Apanteles* sp. was recorded on the larvae of yellow stem borer (Table 12 and Fig. 13). The larval parasitoid activity was noticed between 35th to 41st SMW. The larval parasitism by *Apanteles* sp. was noticed between 11.11 to 25.00% with overall average of 11.28%, where the peak activity of parasitoid was recorded during second week (37th SMW) (25.00%) and fourth week of September (39th SWM) (22.22%). The percentage of larval parasitism was slightly higher during second year trial in conventional method.

Table 12: Extent of parasitization of yellow stem borer larvae in Conventional method (Kharif 2012 and 2013)

Month	Std. Meteo. Weeks	No. of larvae collected			Number of larvae parasitized			Per cent parasitism by <i>Apanteles</i> sp.		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
AUG.	32	0	0	0	0	0	0	0.00	0.00	0.00
	33	0	0	0	0	0	0	0.00	0.00	0.00
	34	7	6	6.5	1	0	0.5	14.29	0.00	7.14
	35	11	9	10	1	2	1.5	9.09	22.22	15.66
SEPT.	36	10	11	10.5	2	2	2	20.00	18.18	19.09
	37	11	12	11.5	2	3	2.5	18.18	25.00	21.59
	38	9	10	9.5	1	2	1.5	11.11	20.00	15.56
	39	6	9	7.5	1	2	1.5	16.67	22.22	19.44
OCT.	40	8	9	8.5	1	1	1	12.50	11.11	11.81
	41	7	6	6.5	1	1	1	14.29	16.67	15.48
	42	4	2	3	0	0	0	0.00	0.00	0.00
	43	0	0	0	0	0	0	0.00	0.00	0.00
Average =		6.08	6.17	6.13	0.83	1.08	0.96	9.68	11.28	10.48

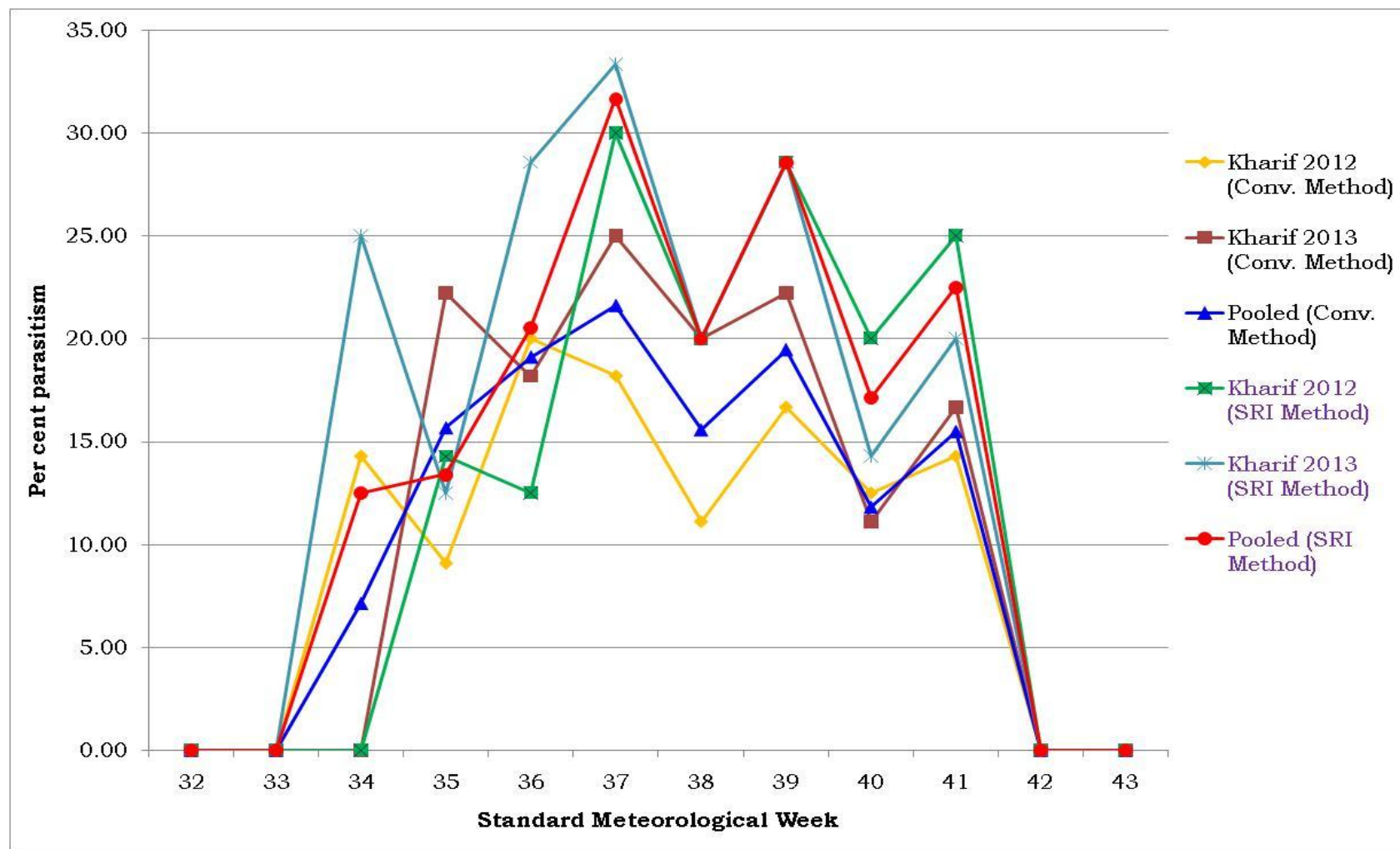


Fig. 13: Extent of parasitization of yellow stem borer larvae in Conventional and SRI method



Plate No. 22: Egg parasitoid (*Tetrastichus schoenobii*) of rice yellow stem borer (*S. incertulas*)



Plate No. 23: Pupa of larval parasitoid (*Apanteles* spp.) of rice yellow stem borer and leaf folder

iii. Pooled:

The pooled results of two years under conventional method (Table 12 and Fig. 13) showed that the larval parasitism by *Apanteles* sp. was ranged from 7.14 to 21.59% with overall average of 10.48%. The larval parasitoid activity was recorded between 34th to 41st SMW. The peak larval parasitism by *Apanteles* sp. was observed 21.59 and 19.44 per cent during second week (37th SMW) and fourth week of September (39th SWM), respectively.

These results are comparable with the information of Chandramohan and Chelliah (1990) who recorded the larval parasitoids, *Apanteles schoenobii* up to 10.26 per cent parasitism during January-February.

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI planting during *Kharif* 2012, the data of the larval parasitism (Table 13 and Fig. 13) revealed that the larval parasitism by *Apanteles* sp. was found between 14.29 to 30.00% with overall average of 12.53%. The larval parasitoid activity was observed between 35th to 41st SMW. However, the peak activity of parasitoid species was occurred in second week (37th SMW) (30.00%) and fourth week of September (39th SWM) (28.57%).

ii. II year (*Kharif* 2013):

The same larval parasitoid, *Apanteles* sp. was also recorded during *Kharif* 2013 on the yellow stem borer (Table 13 and Fig. 13). The larval parasitoid activity was found between 34th to 41st SMW. The larval parasitism by *Apanteles* sp. was ranged from 12.50 to 33.33% with overall average of 15.19%, where the peak activity of parasitoid was found during second week of September (33.33%) and fourth week of September (28.57%). The percentage of parasitism was slightly higher than first year results.

Table 13: Extent of parasitization of yellow stem borer larvae in SRI method (*Kharif* 2012 and 2013)

Month	Std. Meteo. Weeks	No. of larvae collected			Number of larvae parasitized			Per cent parasitism by <i>Apanteles</i> sp.		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
AUG.	32	0	0	0	0	0	0	0.00	0.00	0.00
	33	0	0	0	0	0	0	0.00	0.00	0.00
	34	3	4	3.5	0	1	0.5	0.00	25.00	12.50
	35	7	8	7.5	1	1	1	14.29	12.50	13.39
SEPT.	36	8	7	7.5	1	2	1.5	12.50	28.57	20.54
	37	10	9	9.5	3	3	3	30.00	33.33	31.67
	38	10	10	10	2	2	2	20.00	20.00	20.00
	39	7	7	7	2	2	2	28.57	28.57	28.57
OCT.	40	5	7	6	1	1	1	20.00	14.29	17.14
	41	4	5	4.5	1	1	1	25.00	20.00	22.50
	42	2	3	2.5	0	0	0	0.00	0.00	0.00
	43	0	0	0	0	0	0	0.00	0.00	0.00
Average =		4.67	5.00	4.83	0.92	1.08	1.00	12.53	15.19	13.86

iii. Pooled:

The pooled results of two years under SRI method (Table 13 and Fig. 13) revealed that the larval parasitism by *Apanteles* sp. was observed between 12.50 to 31.67% with overall average of 13.86%. The larval parasitoid activity was noticed between 34th to 41st SMW. The peak parasitism by parasitoid was noticed during second week of September (37th SMW) (31.67%) and fourth week of September (39th SWM) (28.57%).

The activity of larval parasitoid was found higher in SRI method as compared to conventional method.

2. Leaf folder (*C. medinalis*):

A. Conventional method (Transplanting):

i. I year (*Kharif 2012*):

The results on the natural parasitism of leaf folder larvae under conventional planting (Table 14 and Fig. 14) showed that the larvae were parasitized by the Braconid, *Apanteles* sp. The larval parasitoid activity was observed between 36th to 41st SMW. The larval parasitism by *Apanteles* sp. was ranged from 16.67 to 30.00% with overall average of 12.11% during *Kharif 2012*. However, the peak activity of parasitoid species up to 30.00% was occurred in first week of October (40th SMW) where there was high population of leaf folder.

ii. II year (*Kharif 2013*):

During second year (*Kharif 2013*), *Apanteles* sp. was recorded on the larvae of leaf folder (Table 14 and Fig. 14) and the parasitoid activity was noticed between 35th to 42nd SMW. The larval parasitism by *Apanteles* sp. was found between 11.11 to 36.36% with overall average of 14.35%, where the peak activity of parasitoid was recorded during first week of October (40th SMW). The activity of larval parasitism due to *Apanteles* sp. was slightly higher during second year trial in conventional method.

Table 14: Extent of parasitization of leaf folder larvae in Conventional method (*Kharif* 2012 and 2013)

Month	Std. Meteo. Weeks	No. of larvae collected			Number of larvae parasitized			Per cent parasitism by <i>Apanteles</i> sp.		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
AUG.	32	0	0	0	0	0	0	0.00	0.00	0.00
	33	0	0	0	0	0	0	0.00	0.00	0.00
	34	0	0	0	0	0	0	0.00	0.00	0.00
	35	6	5	5.5	0	1	0.5	0.00	20.00	10.00
SEPT.	36	8	9	8.5	2	1	1.5	25.00	11.11	18.06
	37	11	10	10.5	3	2	2.5	27.27	20.00	23.64
	38	12	13	12.5	2	3	2.5	16.67	23.08	19.87
	39	14	15	14.5	3	3	3	21.43	20.00	20.71
OCT.	40	10	11	10.5	3	4	3.5	30.00	36.36	33.18
	41	4	6	5	1	1	1	25.00	16.67	20.83
	42	2	4	3	0	1	0.5	0.00	25.00	12.50
	43	0	0	0	0	0	0	0.00	0.00	0.00
Average =		5.58	6.08	5.83	1.17	1.33	1.25	12.11	14.35	13.23

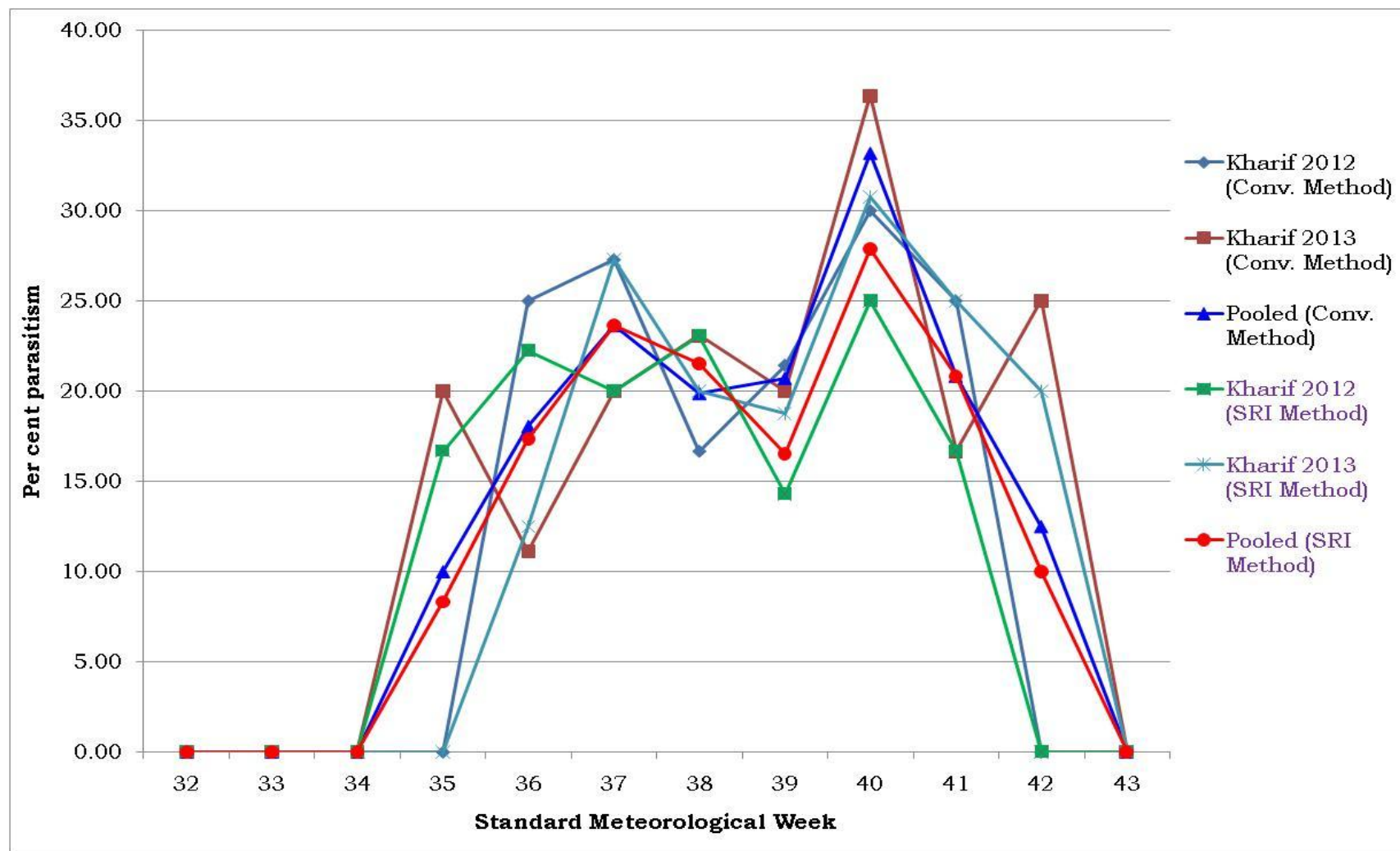


Fig. 14: Extent of parasitization of leaf folder larvae in Conventional and SRI method

iii) Pooled:

The pooled results of two years under conventional method (Table 14 and Fig. 14) showed that the larval parasitism of leaf folder by *Apanteles* sp. was ranged from 10.00 to 33.18% with overall average of 13.26%. The larval parasitoid activity was recorded between 35th to 42nd SMW. The peak larval parasitism by *Apanteles* sp. was observed during first week of October (40th SWM).

In earlier investigations, Islam *et al.* (1996) recorded about 15 parasitoids species were attacked the rice leaf folder and average parasitism in 13 crop seasons was 34.6% (6-45%), which seemed to play an important role in population suppression. While, Dhanapati Devi and Varatharajan (2013) reported seventeen species of parasitoids infecting six insect pests from the rice growing areas of the valley districts of Manipur. These parasitoids belonged to different Hymenopteran families affecting various stages.

B. SRI method:**i. I year (*Kharif* 2012):**

Under SRI planting during *Kharif* 2012, the results of the larval parasitism (Table 15 and Fig. 14) revealed that the larval parasitism of leaf folder by *Apanteles* sp. was recorded between 14.29 to 25.00% with overall average of 11.49%. The larval parasitoid activity was observed between 35th to 41st SMW. However, the peak activity of parasitoid species was occurred in first week of October (40th SMW).

ii. II year (*Kharif* 2013):

The same larval parasitoid, *Apanteles* sp. was also recorded during *Kharif* 2013 on leaf folder (Table 15 and Fig. 14). The larval parasitoid activity was found between 36th to 42nd SMW. The larval parasitism by *Apanteles* sp. was ranged from 12.50 to 30.77% with overall average of 12.86%, where the peak activity of parasitoid was found during first week of October (30.77%). The percentage of parasitism was slightly higher than first year results.

Table 15: Extent of parasitization of leaf folder larvae in SRI method (*Kharif* 2012 and 2013)

Month	Std. Meteo. Weeks	No. of larvae collected			Number of larvae parasitized			Per cent parasitism by <i>Apanteles</i> sp.		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
AUG.	32	0	0	0	0	0	0	0.00	0.00	0.00
	33	0	0	0	0	0	0	0.00	0.00	0.00
	34	0	0	0	0	0	0	0.00	0.00	0.00
	35	6	8	7	1	0	0.5	16.67	0.00	8.33
SEPT.	36	9	8	8.5	2	1	1.5	22.22	12.50	17.36
	37	10	11	10.5	2	3	2.5	20.00	27.27	23.64
	38	13	15	14	3	3	3	23.08	20.00	21.54
	39	14	16	15	2	3	2.5	14.29	18.75	16.52
OCT.	40	12	13	12.5	3	4	3.5	25.00	30.77	27.88
	41	6	8	7	1	2	1.5	16.67	25.00	20.83
	42	4	5	4.5	0	1	0.5	0.00	20.00	10.00
	43	0	0	0	0	0	0	0.00	0.00	0.00
Average =		6.17	7.00	6.58	1.17	1.42	1.29	11.49	12.86	12.18

iii. Pooled:

The pooled results of two years under SRI method (Table 15 and Fig. 14) revealed that the larval parasitism of leaf folder by *Apanteles* sp. was observed between 8.33 to 27.88% with overall average of 12.18%. The larval parasitoid activity was noticed between 35th to 42nd SMW. The peak parasitism by parasitoid was noticed during first week of October (40th SMW). The activity of larval parasitoid was found higher in SRI method as compared to conventional method.

4.1.1.9 Succession of rice pest complex and bio-agents:

A. Conventional method (Transplanting):

The data on population occurrence of rice pest complex in conventional planting method is summarized in Table 16 and Fig. 15 indicated that the incidence of yellow stem borer was started at early stage from tillering till reproductive stage (dough stage). The intensity of stem borer was found fluctuating during crop period and showed two peak activities during heading and flowerings stage. While, the population and infestation of green leaf hopper and brown plant hopper was commenced during heading stage and reached highest in flowering and milk grain stage. Their movement was noticed till the maturity of the crop. The population trend of earhead bug was observed from heading stage and cause maximum crop damage during milky stage, which showed their activity till maturity of the crop.

The leaf damage due to leaf folder was observed after stem elongation and booting stage, which reached highest during flowering stage and thereafter started declining and recorded till dough grain stage. However, the population and incidence of blue beetle was noticed at early tillering stage of rice till flowering only. Their population remained highest during booting stage and then after declined. While in case of sheath mite, the population was observed at late booting stage and reached at peak during flowering and milky stage of the crop and further turn down to low till the harvest of the crop.

Table 16: Succession of rice pest and natural enemies in Conventional Method (Two years pooled)

Month	Std. Meteo. Weeks	Crop growth stage	Infestation of the pest							Activity of natural enemies			
			% DH/WEH of SB	% hill damage by GLH	% hill damage by BPH	Popul. of EHB	% leaf damage by LF	% leaf damage by BB	No. of SM	Popul. of spider	% egg para. of SB	% larval para. of SB	% larval para. of LF
JULY	28	Seedling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	29	Seedling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	30	Seedling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	31	Tillering	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.50	0.00	0.00	0.00
AUG.	32	Tillering	0.66	0.00	0.00	0.00	0.00	1.80	0.00	0.71	0.00	0.00	0.00
	33	Stem elongation	1.65	0.00	0.00	0.00	0.00	2.08	0.00	1.00	12.50	0.00	0.00
	34	Stem elongation	2.24	0.00	0.00	0.00	0.70	2.60	0.00	1.66	16.67	7.14	0.00
	35	Booting	3.47	0.00	0.00	0.00	1.02	2.75	0.83	1.92	20.54	15.66	10.00
SEPT.	36	Heading	5.58	0.29	0.44	1.73	1.59	2.14	2.11	2.65	25.00	19.09	18.06
	37	Heading to panicle exertion	4.57	0.82	0.88	3.83	1.80	1.58	3.95	3.41	33.04	21.59	23.64
	38	Flowering	4.98	1.52	1.89	5.15	2.26	1.05	8.93	3.66	29.17	15.56	19.87
	39	Flowering	5.68	2.08	2.57	6.30	2.30	0.55	15.94	3.92	21.43	19.44	20.71
OCT.	40	Milk grain stage	5.79	2.39	2.82	10.03	2.08	0.00	18.04	4.36	18.33	11.81	33.18
	41	Dough grain stage	3.05	2.15	2.36	8.68	1.63	0.00	13.16	3.57	10.00	15.48	20.83
	42	Dough grain stage	2.19	1.88	2.19	7.05	0.74	0.00	12.08	2.66	0.00	0.00	12.50
	43	Mature grain stage	0.00	1.60	1.84	5.95	0.00	0.00	9.70	2.53	0.00	0.00	0.00

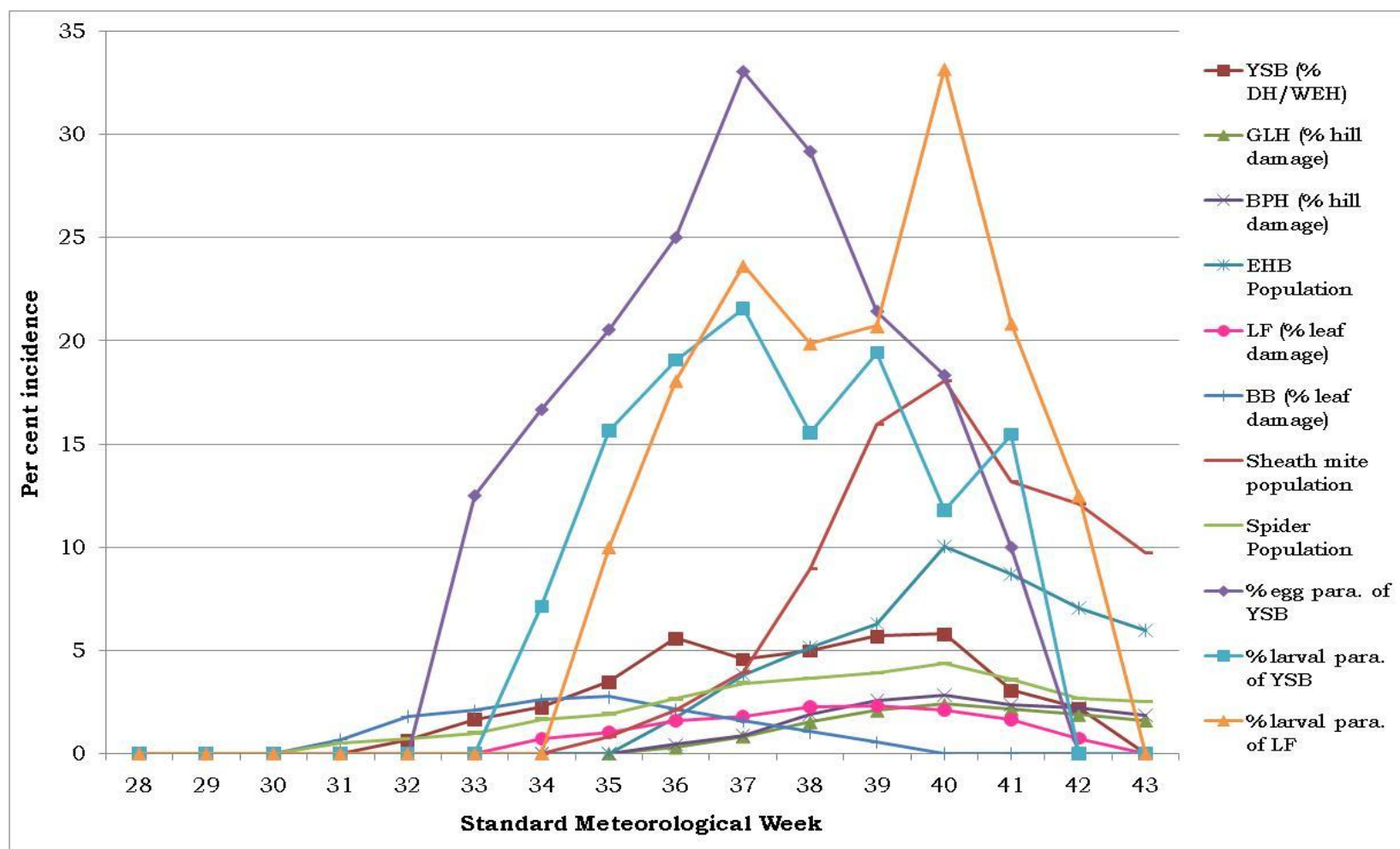


Fig. 15: Succession of rice pest and natural enemies in Conventional Method

Among bio-agents, spider population was initiated with the initiation of the insect pest *i.e.* from tillering stage and showed more or less population fluctuation till the maturity of the rice crop. Their population activity was noticed more in number when there was higher pest pressure *i.e.* from flowering, milky and dough grain stage of the rice. In case of parasitoids, egg parasitism of yellow stem borer was initiated after the start of yellow stem borer damage and reached highest during heading to flowering when there was high pressure of stem borer in the field. Similar trend of larval parasitism of yellow stem borer was found with proportional in the larval population of the pest. The larval parasitism of leaf folder was started at booting stage when the leaf folder observed in the increased inclination and recorded highest parasitism during flowering and milky stage.

B. SRI method:

Under SRI planting method, the results on population incidence of rice pest complex (Table 17 and Fig. 16) also indicated similar type of trend as observed in conventional method. The incidence of yellow stem borer was started from tillering stage till reproductive stage with the peak activity during heading and flowerings stage. The incidence of green leaf hopper and brown plant hopper was commenced from heading stage till the maturity of the crop and reached highest in flowering and milk grain stage. The number of earhead bug was recorded from heading stage and showed maximum population during milky stage, which showed their activity till maturity of the crop.

The leaf folder infestation was recorded from stem elongation and booting stage, which reached highest during flowering stage and recorded till dough grain stage. While, the population of blue beetle was noticed from tillering to flowering stage of rice and reached highest during booting stage. In case of non-insect pest, sheath mite population was commenced at booting stage and reached at peak during flowering and milky stage of the crop and recorded till the harvest of the crop.

Table 17: Succession of rice pest and natural enemies in SRI Method (Two years pooled)

Month	Std. Meteo. Weeks	Crop growth stage	Infestation of the pest							Activity of natural enemies			
			% DH/WEH of SB	% hill damage by GLH	% hill damage by BPH	Popul. of EHB	% leaf damage by LF	% leaf damage by BB	No. of SM	Popul. of spider	% egg para. of SB	% larval para. of SB	% larval para. of LF
JULY	28	Seedling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	29	Seedling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	30	Seedling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	31	Tillering	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.72	0.00	0.00	0.00
AUG.	32	Tillering	0.46	0.00	0.00	0.00	0.00	1.28	0.00	0.88	0.00	0.00	0.00
	33	Stem elongation	0.90	0.00	0.00	0.00	0.00	1.76	0.00	1.16	12.50	0.00	0.00
	34	Stem elongation	1.60	0.00	0.00	0.00	0.70	2.13	0.00	1.79	26.67	12.50	0.00
	35	Booting	2.91	0.00	0.00	0.00	1.13	2.30	0.78	2.07	30.00	13.39	8.33
SEPT.	36	Heading	4.19	0.24	0.21	1.33	1.66	1.73	2.00	2.90	36.67	20.54	17.36
	37	Heading to panicle exertion	3.95	0.69	0.71	2.75	1.89	1.41	3.15	3.71	38.10	31.67	23.64
	38	Flowering	4.02	1.16	1.44	4.05	2.44	0.83	6.06	3.89	33.04	20.00	21.54
	39	Flowering	4.93	1.67	2.42	5.35	2.66	0.37	10.34	4.42	24.29	28.57	16.52
OCT.	40	Milk grain stage	3.84	2.13	2.13	8.90	2.35	0.00	11.95	4.54	26.67	17.14	27.88
	41	Dough grain stage	2.03	1.65	1.92	7.45	1.51	0.00	11.04	3.79	12.50	22.50	20.83
	42	Dough grain stage	1.26	1.42	1.71	5.85	0.60	0.00	8.20	2.99	0.00	0.00	10.00
	43	Mature grain stage	0.00	1.16	1.56	4.83	0.00	0.00	7.09	2.70	0.00	0.00	0.00

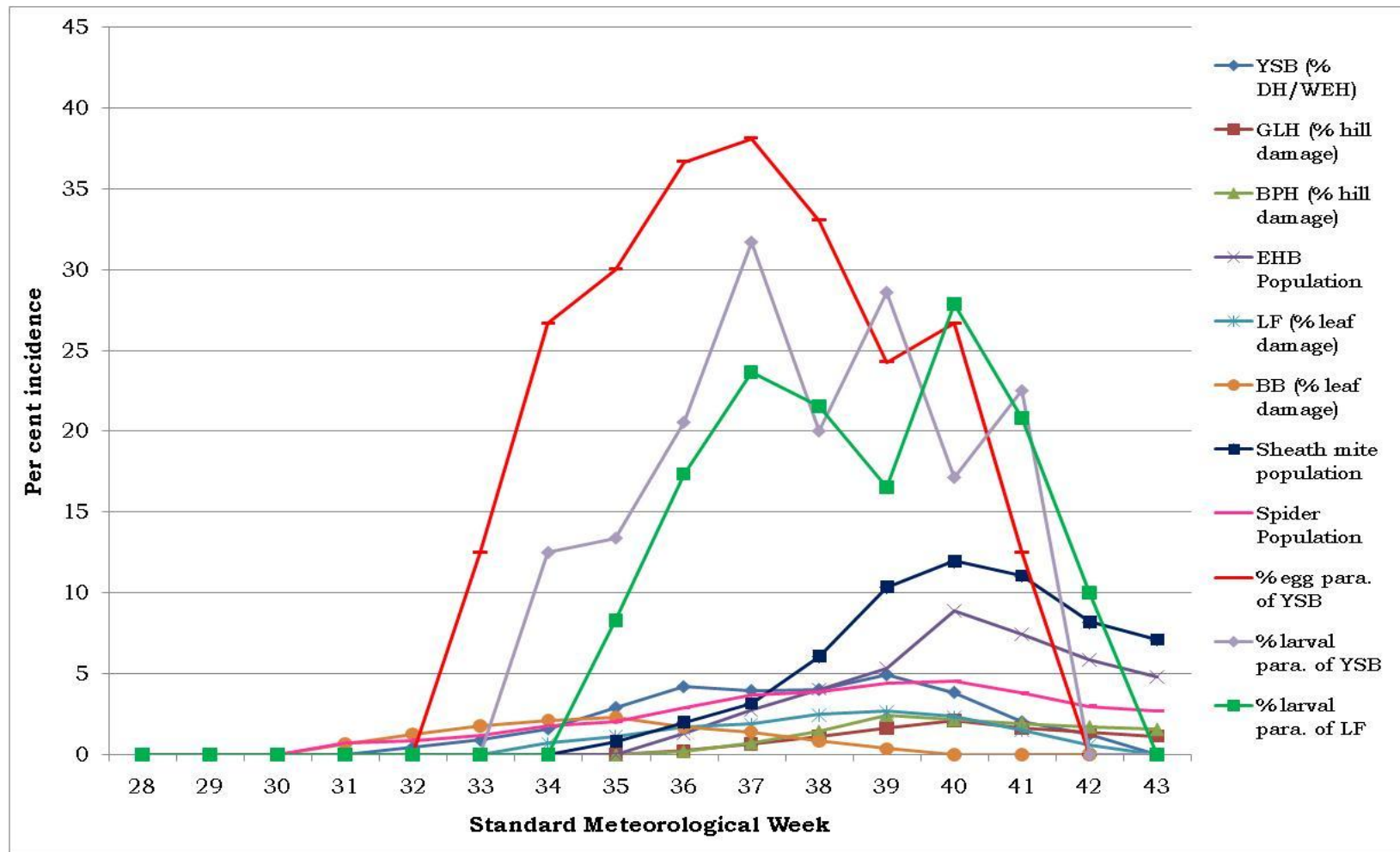


Fig. 16: Succession of rice pest and natural enemies in SRI Method

In case of natural enemies, spider population was noticed with the beginning of the insect pest *i.e.* from tillering stage and showed more or less population fluctuation till the maturity of the rice crop. Their population activity was found more in number when there was higher pest pressure *i.e.* from flowering, milky and dough grain stage of the rice. Among parasitoids, egg and larval parasitism of yellow stem borer was initiated after the initiation of yellow stem borer damage and reached highest during heading to flowering when there was high pressure of stem borer in the field. The leaf folder larval parasitism was initiated at booting stage when the leaf folder observed in the increase tendency and recorded highest parasitism during flowering and milky stage.

These population results of rice pest complex under both the method of rice cultivation showed that SRI method of planting was found effective in lower down the population of yellow stem borer, green leaf hopper, brown plant hopper, earhead bug, blue beetle and sheath mite as compare to than conventional planting method except leaf folder. As well as the parasitoids activity was observed proportional to the population of the insect pests.

Regarding the pest situation in rice ecosystem during the season was explained by various earlier investigators. Among these, Tripathy *et al.* (1999) two peaks of yellow stem borer (*S. incertulas*), of which first was during the last week of September and another during second week of November which coincided with the dough stage of rice. Similarly, Sankpal (2011) observed peak level of *S. incertulas* at vegetative and reproductive stage, while Gole (2012) stated the incidence of *S. incertulas* from early stage to the harvest of the crop,

In case of brown plant hopper, Khaire and Dumbre (1984) found that the adults were reached to peak numbers in November coinciding with flowering, dough and grain formation stages, while Desai (2008) showed that the severity of the pest was seen at the reproductive stage of the crop.

Pushpakumari and Tiwari (2005) noted the population of earhead bug (*L. acuta*) just before flowering of the crop and the highest number was recorded at the milky stage of the crop.

Earlier, Ram (1986) and Kushwaha (1988) reported that infestation of leaf folder (*C. medinalis*) peaked during booting to panicle emergence stage. The leaf folder infestation at grain filling stage was more detrimental which was in accordance with the findings made by Saikia and Parameswaran (1999). In past reports of Anonymous (2010^b) and Gole (2012), standard transplanting (STP) proved most effective planting method against *C. medinalis* in South India, while SRI was found less effective for controlling the insect pests. Thus, the observations in case of STP are accordance with this present report.

Dalvi *et al.* (1985) pointed out that the month of August and September were generally more congenial for rapid build-up of the rice pest.

Regarding natural enemies population occurrence, similar type findings were reported by Anbalagan and Narayanasamy (1999), Khan and Mishra (2003) and Vijaykumar and Patil (2004), wherein they found that the spider population was directly related to growth stages of the rice plants. Likewise, Sankpal (2011) observed the spider population was found to be increased with increasing the incidence of yellow stem borer and leaf folder during the crop period. Manju *et al.* (2002) showed that the egg masses parasitism due to *T. schoenobii* were more numerous at panicle initiation stage than at tillering stage and flowering stages and therefore the parasitism was higher at panicle initiation stage than at flowering and tillering stage.

These results of above mentioned authors are more or less similar and which may be due to change in location wise cultural practices and ecological condition, but confirms the similar trend of the seasonal occurrence.

4.1.2 Correlation of major insect pest incidence with weather parameters in relation to different methods of planting

4.1.2.1 Rice yellow stem borer (*S. incertulas*):

A. Conventional method:

i. I year (*Kharif* 2012):

The correlation co-efficient analysis data (Table 18) of stem borer showed non-significant results with weather factors. Where, minimum temperature ($r = -0.348$) had negative correlation with yellow stem borer incidence, while maximum temperature ($r = 0.108$), relative humidity ($r = 0.177$), rainfall ($r = 0.325$) and bright sunshine ($r = 0.212$) had positive correlation with the yellow stem borer.

ii. II year (*Kharif* 2013):

The correlation results (Table 18) during *Kharif* 2013 season were showed that minimum temperature ($r = -0.027$) and relative humidity ($r = -0.241$) had non-significant negative relationship while, maximum temperature ($r = 0.174$), rainfall ($r = 0.038$) and bright sunshine hrs ($r = 0.263$) had non-significant positive correlation with *S. incertulas*.

Table 18: Correlation of rice yellow stem borer incidence with weather parameters in conventional and SRI method during *Kharif* 2012 and 2013

Method & Year	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Bright Sunshine hrs.
Conventional method (% DH and WEH)					
I year (<i>Kharif</i> 2012)	0.108	-0.348	0.177	0.325	0.212
II year (<i>Kharif</i> 2013)	0.174	-0.027	-0.241	0.038	0.263
Pooled	0.133	-0.194	0.058	0.254	0.233
SRI method (% DH and WEH)					
I year (<i>Kharif</i> 2012)	0.012	-0.291	0.250	0.362	0.118
II year (<i>Kharif</i> 2013)	0.185	-0.095	-0.234	0.091	0.271
Pooled	0.079	-0.193	0.081	0.300	0.186
* Significant at 5% level ($r = 0.482$) and ** at 1% level ($r = 0.606$).					

iii. Pooled:

The pooled data on the correlation co-efficient (Table 18) of yellow stem borer revealed non-significant results with weather factors. Minimum temperature ($r = -0.194$) had negative correlation with stem borer incidence, while maximum temperature ($r = 0.133$), relative humidity ($r = 0.058$), rainfall ($r = 0.254$) and bright sunshine ($r = 0.233$) had positive correlation with the yellow stem borer under conventional method.

In contrast to this, Sarkar and Gayen (1992) from West Bengal and Bhatnagar and Saxena (1999) from Jagdalpur reported a non significant but negative impact of rainfall and significant positive impact of sunshine hrs on stem borer activity and infestation. Padhi and Saha (2004) also reported negative impact of maximum temperature, rainfall, relative humidity and wind velocity, while positively correlation with minimum temperature, evaporation and sunshine hrs to the yellow stem borer moth population.

Further in another report, Kharat (2006) showed the correlation between incidence of stem borer and rainfall, while maximum temperature exhibited non-significant negative correlation, whereas exhibited non-significant positive correlation with minimum temperature, morning, evening and sunshine hrs as well as Sankpal (2011) recorded that maximum temperature as well as bright sunshine hrs had negative correlation with yellow stem borer incidence at pre-harvest, while minimum temperature, morning relative humidity, evening relative humidity and rainfall had positive correlation with the yellow stem borer.

Justin and Preetha (2013) illustrated a significant positive correlation with relative humidity and negative correlation with minimum temperature and rainfall. This might be due to difference in environmental conditions.

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI method, the impact of weather parameters was non-significant at 1% and 5% level significance during first year trial (Table 18). However, positive influence of maximum temperature ($r= 0.012$), relative humidity ($r= 0.250$), rainfall ($r= 0.362$) and bright sunshine hrs ($r= 0.118$) was recorded with stem borer incidence, while negative correlation was found in minimum temperature ($r= -0.291$).

ii. II year (*Kharif* 2013):

The influence of weather parameters on stem borer damage also showed positive non-significant results during second year with maximum temperature ($r= 0.185$), rainfall ($r= 0.091$) and bright sunshine hrs ($r= 0.271$), whereas, negative correlation was found in minimum temperature ($r= -0.095$) and relative humidity ($r= -0.234$) (Table 18).

iii. Pooled:

The pooled data of correlation co-efficient of yellow stem borer infestation with weather factors indicated non-significant results at 1% and 5% level significance in SRI method (Table 18). However, mean population incidence showed positive interaction with maximum temperature ($r= 0.079$), relative humidity ($r= 0.081$), rainfall ($r= 0.300$) and bright sunshine hrs ($r= 0.186$), while negative correlation was recorded with minimum temperature ($r= -0.193$).

These results under conventional and SRI method of planting indicated that the weather parameters had less impact on yellow stem borer infestation as well as no difference found among both type of planting, which justified that the damage was mainly concealed stem borer activity with plant phenology.

With view of Ramakrishnan and Venugopal (1991), stem borer correlation study showed that fitted multiple regression equations explained approximately 50% variation in dead heart/whitehead damage

due to weather, but none of the factors contributed significantly to stem borer infestation. While, Hugar and Venkatesh (2009) studied the influence of weather factors on the infestation of *S. incertulas* in aerobic rice and the results revealed the non-significant and negative correlation with maximum temperature, morning relative humidity and rainfall as well as had significant positive correlation with sunshine hrs in *Kharif*. These findings support the correlation results obtained in present findings.

4.1.2.2 Green leaf hopper (*N. virescens*)

A. Conventional method:

i. I year (*Kharif* 2012):

The correlation results of first year experiment (Table 19) indicated that the green leaf hopper hill damage showed evidence of significant positive correlation with maximum temperature ($r = 0.779$) and sunshine hrs ($r = 0.855$), while significant negative correlation was found in minimum temperature ($r = -0.804$) and relative humidity ($r = -0.510$). Whereas, rainfall ($r = -0.274$) had showed non-significant negative correlation with the damage of green leaf hopper in conventional method of planting.

The findings of population revealed that maximum temperature ($r = 0.815$) and sunshine hrs ($r = 0.877$) had significant positive correlation with the nymph and adult population of rice green leaf hopper, while minimum temperature ($r = -0.790$) and relative humidity ($r = -0.523$) had significant negative correlation with the nymph and adult population. Rainfall ($r = -0.280$) had non-significant negative correlation with the nymph and adult population of green leaf hopper in conventional method (Table 19).

ii. II year (*Kharif* 2013):

The results coefficient correlation of rice green leaf hopper recorded under conventional method during *Kharif* 2013 and depicted in Table 19 revealed that maximum temperature ($r = 0.594$) and bright

sunshine hrs ($r = 0.764$) had significant positive correlation with the hill damage, while relative humidity ($r = -0.517$) had significant negative correlation with the infestation. Minimum temperature ($r = -0.342$) had non-significant negative correlation with the damage of rice green leaf hopper, while rainfall ($r = 0.327$) had non-significant positive correlation with the infestation.

The correlation of nymphal and adult population with weather parameters under conventional method showed that maximum temperature ($r = 0.575$) and bright sunshine hrs ($r = 0.734$) had significant positive correlation with the population of rice green leaf hopper. Minimum temperature ($r = -0.278$) and relative humidity ($r = -0.466$) had non-significant negative correlation with the population of rice green leaf hopper, while rainfall ($r = 0.315$) had non-significant positive coefficient (Table 19).

iii. Pooled:

The pooled results of coefficient correlation in conventional method of planting (Table 19) revealed that the green leaf hoppers hill damage exhibited significant positive correlation with maximum temperature ($r = 0.764$) and bright sunshine hrs ($r = 0.843$), while significant negative influence was found in minimum temperature ($r = -0.661$) and relative humidity ($r = -0.579$). However, rainfall ($r = 0.197$) had showed non-significant positive correlation with the hill damage of rice green leaf hopper.

The pooled correlation data of the nymphs and adults population of green leaf hopper (Table 19) indicated that maximum temperature ($r = 0.768$) and sunshine hrs ($r = 0.836$) had significant positive correlation, while minimum temperature ($r = -0.622$) and relative humidity ($r = -0.544$) had significant negative correlation with the nymph and adult population in conventional method. However, rainfall ($r = 0.311$) had non-significant positive correlation with the nymph and adult population of green leaf hopper.

Table 19: Correlation of rice green leaf hopper incidence and population with weather parameters in conventional and SRI method during Kharif 2012 and 2013

Method & Year	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Bright Sunshine hrs.
Conventional method (% hill damage)					
I year (<i>Kharif</i> 2012)	0.779**	-0.804**	-0.510*	-0.274	0.855**
II year(<i>Kharif</i> 2013)	0.594*	-0.342	-0.517*	0.327	0.764**
Pooled	0.764**	-0.661**	-0.579*	0.197	0.843**
SRI method (% hill damage)					
I year (<i>Kharif</i> 2012)	0.772**	-0.791**	-0.494*	-0.260	0.849**
II year(<i>Kharif</i> 2013)	0.513*	-0.281	-0.495*	0.336	0.692**
Pooled	0.729**	-0.617**	-0.531*	0.192	0.807**
Conventional method (GLH Population)					
I year(<i>Kharif</i> 2012)	0.815**	-0.790**	-0.523*	-0.280	0.877**
II year(<i>Kharif</i> 2013)	0.575**	-0.278	-0.466	0.315	0.734**
Pooled	0.768**	-0.622**	-0.544**	0.311	0.836**
SRI method (GLH Population)					
I year(<i>Kharif</i> 2012)	0.797**	-0.770**	-0.497*	-0.278	0.855**
II year(<i>Kharif</i> 2013)	0.570**	-0.296	-0.486*	0.322	0.738**
Pooled	0.751**	-0.620**	-0.555**	0.202	0.822**
* Significant at 5% level ($r = 0.482$) and ** at 1% level ($r = 0.606$).					

Earlier more or less correlation results were obtained in the finding of Kharat (2006) who found green leaf hopper population and maximum temperature, morning relative humidity and sunshine hrs were positively non-significant, while rainfall and evening relative humidity were negative non-significantly correlated with pest population. Shamim *et al.* (2009) from Middle Gujarat region indicated that the bright sunshine hrs had a positive significant correlation with the population dynamics of green leafhopper, which match with present finding, but in contrast maximum temperature, minimum temperature, rainfall and relative humidity showed non-significant effect on population build-up of green leaf hopper.

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI method of planting, the first year results of correlation (Table 19) revealed that the green leaf hopper leaf damage demonstrated significant positive correlation with maximum temperature ($r = 0.772$) and sunshine hrs ($r = 0.849$), while significant negative correlation was obtained in minimum temperature ($r = -0.791$) and relative humidity ($r = -0.494$). Whereas, rainfall ($r = -0.260$) had showed non-significant negative correlation with the damage of green leaf hopper.

The data on population under SRI method (Table 19) showed that maximum temperature ($r = 0.797$) and sunshine hrs ($r = 0.855$) had significant positive correlation with the nymph and adult population of rice green leaf hopper, while minimum temperature ($r = -0.770$) and relative humidity ($r = -0.497$) had significant negative correlation with the nymph and adult population. Rainfall ($r = -0.278$) exhibited non-significant negative correlation with the nymph and adult population of green leaf hopper.

ii. II year (*Kharif* 2013):

The coefficient correlation data recorded during *Kharif* 2013 and elaborated in Table 19 revealed that maximum temperature ($r = 0.513$) and bright sunshine hrs ($r = 0.692$) had significant positive influence on the hill damage of green leaf hopper, while relative humidity ($r = -0.495$) had significant negative correlation with the infestation under SRI method. However, minimum temperature ($r = -0.281$) had non-significant negative and rainfall ($r = 0.336$) non-significant positive correlation with the damage of green leaf hopper.

The correlation of nymphal and adult population with weather parameters (Table 19) indicated that maximum temperature ($r = 0.570$) and bright sunshine hrs ($r = 0.738$) had significant positive correlation, while relative humidity ($r = -0.486$) had significant negative correlation with the population of rice green leaf hopper. Minimum temperature

($r = -0.296$) had non-significant negative, while rainfall ($r = 0.322$) non-significant positive correlation with the population of rice green leaf hopper.

iii. Pooled:

The pooled results of coefficient correlation in SRI method are depicted in Table 19 revealed that the rice green leaf hopper hill damage exhibited significant positive correlation with maximum temperature ($r = 0.729$) and sunshine hrs ($r = 0.807$), while significant negative correlation was found in minimum temperature ($r = -0.617$) and relative humidity ($r = -0.531$). However, rainfall ($r = 0.192$) had showed non-significant positive correlation with the damage of green leaf hopper.

The pooled correlation data of the nymph and adult population of green leaf hopper with weather parameters (Table 19) indicated that maximum temperature ($r = 0.751$) and sunshine hrs ($r = 0.822$) had significant positive correlation, while minimum temperature ($r = -0.620$) and relative humidity ($r = -0.555$) had significant negative correlation with the nymph and adult population in SRI method. However, rainfall ($r = 0.202$) had non-significant positive correlation with the nymph and adult population of rice green leaf hopper.

The two years results revealed that the maximum temperature and bright sunshine hrs influence the hill damage and the population of the rice green leaf hopper positively, while minimum temperature and relative humidity showed their negative effect. Rainfall did not showed any major corollary effect on the hill damage and population of the green leaf hopper under conventional and SRI method of planting.

4.1.2.3 Brown plant hopper (*N. lugens*)

A. Conventional method:

i. I year (*Kharif* 2012):

The correlation results of first year trial presented in Table 20 indicated that the brown plant hopper hill damage exhibited significant positive correlation with maximum temperature ($r = 0.739$) and sunshine

hrs ($r = 0.827$), while significant negative correlation was observed with minimum temperature ($r = -0.802$) and relative humidity ($r = -0.488$). Whereas, rainfall ($r = -0.231$) had showed non-significant negative correlation with the damage of brown plant hopper in conventional method of planting.

The findings of correlation (Table 20) showed that maximum temperature ($r = 0.785$) and sunshine hrs ($r = 0.863$) had significant positive correlation with the nymph and adult population of rice brown plant hopper, while minimum temperature ($r = -0.811$) and relative humidity ($r = -0.515$) had significant negative correlation with the nymph and adult population. Rainfall ($r = -0.225$) had non-significant negative correlation with the nymph and adult population of brown plant hopper in conventional method.

ii. II year (*Kharif* 2013):

The results coefficient correlation recorded during *Kharif* 2013 (Table 20) revealed that maximum temperature ($r = 0.569$) and bright sunshine hrs ($r = 0.744$) had significant positive correlation with the hill damage of rice brown plant hopper, while relative humidity ($r = -0.494$) had significant negative correlation with the infestation under conventional method. Minimum temperature ($r = -0.301$) had non-significant negative correlation with the damage of rice brown plant hopper, while rainfall ($r = 0.315$) had non-significant positive correlation with the infestation.

The nymphal and adult population correlation with weather parameters (Table 20) showed that maximum temperature ($r = 0.612$) and bright sunshine hrs ($r = 0.775$) had significant positive correlation, while relative humidity ($r = -0.501$) had significant negative correlation with the population of rice brown plant hopper. Minimum temperature ($r = -0.336$) had non-significant negative correlation with the population of rice brown plant hopper, while rainfall ($r = 0.313$) had non-significant positive correlation.

iii. Pooled:

The pooled results of coefficient correlation presented in Table 20 revealed that the brown plant hoppers hill damage exhibited significant positive correlation with maximum temperature ($r = 0.742$) and sunshine hrs ($r = 0.829$), while significant negative correlation was found in minimum temperature ($r = -0.649$) and relative humidity ($r = -0.568$). However, rainfall ($r = 0.195$) had showed non-significant positive correlation with the damage of brown plant hopper in conventional method of planting.

The pooled data of the nymph and adult population of rice brown plant hopper correlation (Table 20) indicated that maximum temperature ($r = 0.782$) and sunshine hrs ($r = 0.859$) had significant positive correlation, while minimum temperature ($r = -0.670$) and relative humidity ($r = -0.593$) had significant negative correlation with the nymph and adult population in conventional method. However, rainfall ($r = 0.212$) had non-significant positive correlation with the nymph and adult population of rice brown plant hopper.

These results are concerned with the findings of Jeyarani (2004) wherein he found negative correlation with excessive rainfall and showed non-significant relationship with other weather parameters. While, slight dissimilarity was found earlier in the results of Narayanasamy *et al.* (1979) who found positive correlation of rice brown plant hopper with higher humidity and negative correlation with rainfall and temperature, which may be due to change of locations.

In the findings of Desai (2008), the damage of brown plant hopper had significant positive correlation with maximum temperature, whereas significant negative correlation with minimum temperature, relative humidity and rainy days in *Kharif*. Similarly, the nymphal population of rice brown plant hopper had significant positive correlation with maximum temperature, whereas minimum temperature, relative humidity had significant negative correlation. These findings strongly confirms the present correlation data as well as also match with the

observations of Chander and Palta (2010), who stated that temperature, cloudy weather and well distributed intermittent rainfall and relatively calm conditions leading to high humidity during June-August in 2008 were quite favourable for the BPH growth and multiplication.

The correlation coefficient data of Kharat (2006) revealed that positive significant correlation existed between pest population and maximum temperature and sunshine hrs. The evening humidity and average humidity exhibited negatively significantly correlation with pest population. The pest population was negatively non significant with rainfall, minimum temperature and morning humidity.

Table 20: Correlation of rice brown plant hopper incidence and population with weather parameters in conventional and SRI method during Kharif 2012 and 2013

Method & Year	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Bright Sunshine hrs.
Conventional method (% hill damage)					
I year (<i>Kharif</i> 2012)	0.739**	-0.802**	-0.488*	-0.231	0.827**
II year(<i>Kharif</i> 2013)	0.569*	-0.301	-0.494*	0.315	0.744**
Pooled	0.742**	-0.649**	-0.568*	0.195	0.829**
SRI method (% hill damage)					
I year (<i>Kharif</i> 2012)	0.732**	-0.801**	-0.486*	-0.268	0.810**
II year(<i>Kharif</i> 2013)	0.556*	-0.340	-0.519*	0.342	0.739**
Pooled	0.725**	-0.665**	-0.575*	0.238	0.815**
Conventional method (BPH Population)					
I year (<i>Kharif</i> 2012)	0.785**	-0.811**	-0.515*	-0.225	0.863**
II year(<i>Kharif</i> 2013)	0.612**	-0.336	-0.501*	0.313	0.775**
Pooled	0.782**	-0.670**	-0.593*	0.212	0.859**
SRI method (BPH Population)					
I year (<i>Kharif</i> 2012)	0.759**	-0.782**	-0.492*	-0.268	0.825**
II year(<i>Kharif</i> 2013)	0.508*	-0.310	-0.488*	0.396	0.693**
Pooled	0.723**	-0.631**	-0.558*	0.258	0.804**
* Significant at 5% level ($r = 0.482$) and ** at 1% level ($r = 0.606$).					

B. SRI method:

i. I year (*Kharif* 2012):

under SRI method of planting, the first year result of correlation presented in Table 20 indicated that the brown plant hopper hill damage demonstrated significant positive correlation with maximum temperature ($r = 0.732$) and sunshine hrs ($r = 0.810$), while significant negative correlation was obtained in minimum temperature ($r = -0.801$) and relative humidity ($r = -0.486$). Whereas, rainfall ($r = -0.268$) had showed non-significant negative correlation with the damage of rice brown plant hopper.

The correlation data (Table 20) showed that maximum temperature ($r = 0.759$) and sunshine hrs ($r = 0.825$) had significant positive correlation with the nymph and adult population of rice brown plant hopper, while minimum temperature ($r = -0.782$) and relative humidity ($r = -0.492$) had significant negative correlation with the nymph and adult population. Rainfall ($r = -0.268$) had non-significant negative correlation with the nymph and adult population of brown plant hopper.

ii. II year (*Kharif* 2013):

The coefficient correlation data recorded during *Kharif* 2013 and elaborated in Table 20 revealed that maximum temperature ($r = 0.556$) and bright sunshine hrs ($r = 0.739$) had significant positive correlation with the hill damage of rice brown plant hopper, while relative humidity ($r = -0.519$) had significant negative correlation with the infestation under conventional method. However, minimum temperature ($r = -0.340$) had non-significant negative correlation and rainfall ($r = 0.342$) had non-significant positive correlation with the damage of brown plant hopper.

The correlation of nymphal and adult population with weather parameters (Table 20) indicated that maximum temperature ($r = 0.508$) and bright sunshine hrs ($r = 0.693$) had significant positive correlation, while relative humidity ($r = -0.488$) had significant negative correlation with the population of rice brown plant hopper. Minimum temperature

($r = -0.310$) had non-significant negative correlation, while rainfall ($r = 0.396$) had non-significant positive correlation with the population of rice brown plant hopper.

iii. Pooled:

The pooled data on coefficient correlation (Table 20) revealed that the rice brown plant hopper hill damage exhibited significant positive correlation with maximum temperature ($r = 0.725$) and sunshine hrs ($r = 0.815$), while significant negative correlation was found in minimum temperature ($r = -0.665$) and relative humidity ($r = -0.575$). However, rainfall ($r = 0.238$) had showed non-significant positive correlation with the damage of brown plant hopper in conventional method of planting.

The pooled correlation data of the nymph and adult population of brown plant hopper (Table 20) indicated that maximum temperature ($r = 0.723$) and sunshine hrs ($r = 0.804$) had significant positive correlation, while minimum temperature ($r = -0.631$) and relative humidity ($r = -0.558$) had significant negative correlation with the nymph and adult population in SRI method. However, rainfall ($r = 0.228$) had non-significant positive correlation with the nymph and adult population of rice brown plant hopper.

The two years data revealed that the maximum temperature and bright sunshine hrs influence the hill damage and the population of the rice brown plant hopper positively, while minimum temperature and relative humidity showed their effect negatively. Rainfall did not showed any major consequence on the hill damage and the population of the brown plant hopper under conventional and SRI method of planting.

4.1.2.4 Rice earhead bug (*L. acuta*)

A. Conventional method:

i. I year (*Kharif* 2012):

The findings of first year correlation given in Table 21 showed that maximum temperature ($r = 0.772$) and sunshine hrs ($r = 0.855$) had significant positive correlation with the nymph and adult population of

rice earhead bug, while minimum temperature ($r = -0.793$) and relative humidity ($r = -0.490$) had significant negative correlation with the nymph and adult population in conventional method of planting. However, rainfall ($r = -0.233$) had non-significant negative correlation with the nymph and adult population of rice earhead bug.

ii. II year (*Kharif* 2013):

The nymphal and adult population correlation with weather parameters under conventional planting (Table 21) showed significant positive correlation with maximum temperature ($r = 0.618$) and bright sunshine hrs ($r = 0.765$), while relative humidity ($r = -0.500$) had significant negative correlation with the population of rice earhead bug. Minimum temperature ($r = -0.312$) had non-significant negative coefficient with the population of rice earhead bug, while rainfall ($r = 0.259$) indicated non-significant positive correlation.

iii. Pooled:

The pooled data on the nymph and adult population of rice earhead bug correlation is illustrated in Table 21 indicated that maximum temperature ($r = 0.777$) and sunshine hrs ($r = 0.847$) had significant positive correlation, while minimum temperature ($r = -0.648$) and relative humidity ($r = -0.565$) had significant negative correlation with the nymph and adult population in conventional planting method. However, rainfall ($r = 0.170$) had non-significant positive correlation with the nymph and adult population of rice earhead bug.

These results are supported by the findings of Ghule (2006), who showed maximum temperature and sunshine hrs had significant positive correlation, while evening relative humidity showed significant negative correlation with earhead bug population during *Kharif* season. Similarly, Kharat (2006) indicated that gundhi bug population was negative significantly correlated with minimum temperature, morning relative humidity and evening relative humidity. The correlation between pest population and maximum temperature and sunshine hour was

positively significant while it was negative non-significantly correlated with rainfall. However, some slight difference was recorded in the correlation matrices study of Deore (2002) indicated that earhead bug (*L. acuta*) population and weather parameters were non-significant indicating that there was no correlation between them. There existed a significant positive correlation between bug population and maximum temperature only.

Table 21: Correlation of rice earhead bug incidence with weather parameters in conventional and SRI method during *Kharif* 2012 and 2013

Method & Year	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Bright Sunshine hrs.
Conventional method (No./5 net sweep)					
I year (<i>Kharif</i> 2012)	0.772**	-0.793**	-0.490*	-0.233	0.855**
II year(<i>Kharif</i> 2013)	0.618**	-0.312	-0.500*	0.259	0.765**
Pooled	0.777**	-0.648**	-0.565*	0.170	0.847**
SRI method (No./5 net sweep)					
I year (<i>Kharif</i> 2012)	0.781**	-0.779**	-0.485*	-0.245	0.855**
II year(<i>Kharif</i> 2013)	0.579*	-0.286	-0.486*	0.275	0.726**
Pooled	0.764**	-0.622**	-0.549*	0.174	0.830**
* Significant at 5% level ($r = 0.482$) and ** at 1% level ($r = 0.606$).					

B. SRI method:

i. I year (*Kharif* 2012):

The correlation results of first year depicted in Table 21 showed that maximum temperature ($r = 0.781$) and sunshine hrs ($r = 0.855$) had significant positive correlation with the nymph and adult population of rice earhead bug, while minimum temperature ($r = -0.779$) and relative humidity ($r = -0.485$) had significant negative correlation with the nymph and adult population under SRI planting method. Rainfall ($r = -0.245$) had non-significant negative correlation with the nymph and adult population of rice earhead bug.

ii. II year (*Kharif* 2013):

During second year, the correlation of nymphal and adult population with weather parameters (Table 21) indicated that maximum temperature ($r= 0.579$) and bright sunshine hrs ($r= 0.726$) had significant positive influence, while relative humidity ($r= -0.486$) had significant negative effect on the population of rice earhead bug. Minimum temperature ($r= -0.286$) had non-significant negative correlation, while rainfall ($r= 0.275$) had non-significant positive correlation with the population of rice earhead bug.

iii. Pooled:

The pooled data of the nymph and adult population of earhead bug correlation under SRI method is given in Table 20 revealed that maximum temperature ($r= 0.764$) and sunshine hrs ($r= 0.830$) had significant positive influence, while minimum temperature ($r= -0.622$) and relative humidity ($r= -0.549$) had significant negative correlation with the nymph and adult population. However, rainfall ($r= 0.174$) had non-significant positive correlation with the nymph and adult population of rice earhead bug.

The two years data revealed that the maximum temperature and bright sunshine hrs positively control the population of the rice earhead bug, while minimum temperature and relative humidity showed their negative end result. Rainfall did not showed any major consequence on the population built up of the earhead bug, but caused positive relation impact under conventional and SRI method of planting.

4.1.2.5 Rice leaf folder (*C. medinalis*)**A. Conventional method:****i. I year (*Kharif* 2012):**

The correlation co-efficient study during *Kharif* 2012 (Table 22) indicated that maximum temperature ($r= 0.133$), relative humidity ($r= 0.176$) rainfall ($r= 0.256$) and bright sunshine hrs ($r= 0.225$) had non-significant positive relationship with *C. medinalis* infestation under

conventional method of planting. While, minimum temperature ($r = -0.341$) had negative association with the infestation of *C. medinalis*.

ii. II year (Kharif 2013):

Based on correlation co-efficient of second year study (Table 22), it is found that maximum temperature ($r = 0.230$), rainfall ($r = 0.309$) and bright sunshine hrs ($r = 0.389$) had non-significant positive relationship with *C. medinalis* incidence. Minimum temperature ($r = -0.059$) and relative humidity ($r = -0.248$) had negative association with the infestation of leaf folder.

iii. Pooled:

The pooled results of correlation co-efficient (Table 22) indicated that maximum temperature ($r = 0.216$), relative humidity ($r = 0.002$), rainfall ($r = 0.386$) and sunshine hrs ($r = 0.330$) had non-significant positive correlation with leaf damage of leaf folder under conventional method of planting, while minimum temperature ($r = -0.254$) had non-significant negative correlation with leaf folder population damage.

Correlation studies carried out at Rajendranagar by Kumar *et al.* (2003) revealed a significantly negative association with morning relative humidity. The relationship with rainfall and rainy days was negative, while it was positive with temperature and sunshine hrs but non-significant. Patel (2006) exhibited significant positive correlation with maximum temperature and sunshine hrs, while non-significant negative correlation was observed with minimum temperature and morning relative humidity. These earlier reports support the present findings.

In contrast to this, Kaul and Singh (1999) reported that there was a significant positive correlation between *C. medinalis* infestation with rainfall and frequency of rainy days at Kangra valley as well as Bhatnagar and Saxena (1999) from Jagdalpur reported that *C. medinalis* showed a significantly negative correlation with minimum temperature, evening relative humidity and rainfall and a positive correlation with sunshine hrs and maximum temperature. The results of Manisegaram

and Letchoumanane (2001) showed that a unit increase in the minimum temperature caused an increase in the population of rice leaf folder adults, while there was negative correlation between leaf folder population and relative humidity.

While other earlier reports, Kharat (2006) revealed leaf folder incidence exhibited non-significant positive correlation with maximum temp., minimum temp, average humidity and sunshine hrs. The correlation between leaf folder and rainfall and evening humidity were negatively non-significant. This might be due to difference in environmental conditions and locations. Sankpal (2011) found variance in results, wherein he indicated that the maximum temperature and bright sunshine hrs had significant positive relationship with *C. medinalis* population. Minimum temperature, relative humidity and rainfall had negative association with the population of *C. medinalis*. These variations in the results might be due to alteration in ecological conditions.

Table 22: Correlation of rice leaf folder incidence with weather parameters in conventional and SRI method during Kharif 2012 and 2013

Method & Year	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Bright Sunshine hrs.
Conventional method (% leaf damage)					
I year (<i>Kharif</i> 2012)	0.133	-0.341	0.176	0.256	0.225
II year(<i>Kharif</i> 2013)	0.230	-0.059	-0.248	0.309	0.389
Pooled	0.216	-0.254	0.002	0.386	0.330
SRI method (% leaf damage)					
I year (<i>Kharif</i> 2012)	0.151	-0.342	0.181	0.229	0.234
II year(<i>Kharif</i> 2013)	0.181	-0.047	-0.254	0.249	0.338
Pooled	0.176	-0.232	0.020	0.373	0.290
* Significant at 5% level ($r = 0.482$) and ** at 1% level ($r = 0.606$).					

B. SRI method:

i. I year (*Kharif* 2012):

The correlation co-efficient for relationship between infestation of rice leaf folder and weather parameters under SRI method during *kharif* 2012 are presented in Table 22. The results revealed that larval population of rice leaf folder had non-significant positive correlation with maximum temperature ($r = 0.151$), relative humidity ($r = 0.181$), rainfall ($r = 0.229$) and sunshine hrs ($r = 0.234$) as well as non-significant negative correlation with minimum temperature ($r = -0.342$).

ii. II year (*Kharif* 2013):

The correlation co-efficient during *Kharif* 2013 (Table 22) showed that maximum temperature ($r = 0.181$), rainfall ($r = 0.249$) and bright sunshine hrs ($r = 0.338$) had non-significant positive relationship with *C. medinalis* incidence in rice. However, minimum temperature ($r = -0.047$) and relative humidity ($r = -0.254$) had negative association with the infestation of *C. medinalis*.

iii. Pooled:

The pooled data on correlation co-efficient with weather parameters under SRI method of planting (Table 22) revealed that maximum temperature ($r = 0.176$), relative humidity ($r = 0.020$), rainfall ($r = 0.373$) and sunshine hrs ($r = 0.290$) had non-significant positive relationship with leaf damage of leaf folder under conventional method of rice planting. While, minimum temperature ($r = -0.232$) had non-significant negative correlation with leaf folder population damage under SRI method.

These results under conventional and SRI method of planting indicated that the weather parameters had less impact on leaf folder damage as well as no difference found among both type of planting, which justified that the damage was mainly concealed leaf folder activity with plant phenology.

4.1.2.6 Rice blue beetle (*L. pygmaea*)

A. Conventional method:

i. I year (*Kharif* 2012):

The correlation result of first year trial presented in Table 23 indicated that the rice blue beetle leaf damage exhibited significant negative correlation with maximum temperature ($r = -0.611$) and bright sunshine hrs ($r = -0.558$), while significant positive correlation was observed with relative humidity ($r = 0.486$). Whereas, minimum temperature ($r = 0.257$) and rainfall ($r = 0.438$) had showed non-significant positive correlation with the leaf damage of rice blue beetle in conventional method of planting.

The findings blue beetle population showed that maximum temperature ($r = -0.574$) and sunshine hrs ($r = -0.560$) had significant negative correlation with the adult population of rice blue beetle, while minimum temperature ($r = 0.279$) and relative humidity ($r = 0.450$) and rainfall ($r = 0.354$) had non-significant positive correlation with the adult population of rice blue beetle (Table 23).

ii. II year (*Kharif* 2013):

The results of coefficient correlation analyzed during *Kharif* 2013 (Table 23) revealed non-significant findings. However among them, maximum temperature ($r = -0.199$), rainfall ($r = -0.423$) and bright sunshine hrs ($r = -0.409$) had negative effect on leaf damage of blue beetle, which were differ from first year results. While, minimum temperature ($r = 0.115$) and relative humidity ($r = 0.168$) had positive influence on the infestation of blue beetle under conventional method.

The blue beetle adult population correlation with weather factors (Table 23) indicated non-significant effect, where maximum temperature ($r = -0.174$), rainfall ($r = -0.370$) and bright sunshine hrs ($r = -0.3478$) had negative pressure, while minimum temperature ($r = 0.072$) and relative humidity ($r = 0.129$) had positive correlation with the population of rice blue beetle.

iii. Pooled:

The pooled result of coefficient correlation (Table 23) revealed that the rice blue beetle leaf damage conventional method of planting exhibited significant negative correlation with sunshine hrs ($r = -0.484$), while maximum temperature ($r = -0.433$) and rainfall ($r = -0.236$) had showed non-significant negative influence. However, non-significant positive correlation was found in minimum temperature ($r = 0.212$) and relative humidity ($r = 0.386$) with the damage of blue beetle in conventional method.

The pooled coefficient correlation data of blue beetle adult population (Table 23) indicated that bright sunshine hrs ($r = -0.485$) had significant negative effect, whereas, maximum temperature ($r = -0.441$) and rainfall ($r = -0.178$) caused non-significant negative impact on the population of blue beetle. Further, minimum temperature ($r = 0.212$) and relative humidity ($r = 0.380$) had non-significant positive correlation with the adult population of blue beetle in conventional method of rice planting.

Patel (2008) showed that evening and average relative humidity had significant positive correlation with the adult population of blue beetle, while maximum temperature had significant negative correlation with the adult population of blue beetle. Minimum temperature, morning relative humidity and rainfall had non-significant positive correlation, while sunshine hrs had non-significant negative correlation with the adult population of blue beetle. Kharat (2006) revealed that the blue beetle incidence and minimum and maximum temperature, morning and average relative humidity and sunshine hrs exhibited positive non-significant correlation. The correlation between rice blue beetle incidence and rainfall and evening relative humidity was negatively non-significant. These above results are more or less match with the current findings.

Table 23: Correlation of rice blue beetle incidence and population with weather parameters in conventional and SRI method during Kharif 2012 and 2013

Method & Year	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Bright Sunshine hrs.
Conventional method (% leaf damage)					
I year (<i>Kharif</i> 2012)	-0.611**	0.257	0.486*	0.438	-0.558*
II year (<i>Kharif</i> 2013)	-0.199	0.115	0.168	-0.423	-0.409
Pooled	-0.433	0.212	0.386	-0.236	-0.484*
SRI method (% leaf damage)					
I year (<i>Kharif</i> 2012)	-0.635**	0.286	0.483*	0.423	-0.579*
II year (<i>Kharif</i> 2013)	-0.170	0.092	0.155	-0.414	-0.382
Pooled	-0.428	0.214	0.386	-0.248	-0.485*
Conventional method (BB Population)					
I year (<i>Kharif</i> 2012)	-0.574*	0.279	0.450	0.354	-0.560*
II year (<i>Kharif</i> 2013)	-0.174	0.072	0.129	-0.370	-0.348
Pooled	-0.441	0.212	0.380	-0.178	-0.485*
SRI method (BB Population)					
I year (<i>kharif</i> 2012)	-0.534*	0.315	0.420	0.287	-0.550*
II year (<i>kharif</i> 2013)	-0.123	0.029	0.119	-0.403	-0.325
Pooled	-0.405	0.225	0.375	-0.220	-0.484*
* Significant at 5% level ($r = 0.482$) and ** at 1% level ($r = 0.606$).					

B. SRI method:**i. I year (*Kharif* 2012):**

Under SRI method of planting, the first year result of correlation (Table 23) indicated that the blue beetle leaf damage demonstrated significant negative correlation with maximum temperature ($r = -0.635$) and bright sunshine hrs ($r = -0.579$), while significant positive results was obtained in relative humidity ($r = 0.483$). Whereas, minimum temperature ($r = 0.286$) and rainfall ($r = 0.423$) had showed non-significant positive correlation with damage of blue beetle.

The weather parameters *viz.*, maximum temperature ($r = -0.534$) and bright sunshine hrs ($r = -0.550$) showed significant negative

influence with the adult population of rice blue beetle, while minimum temperature ($r = 0.315$), relative humidity ($r = 0.420$) and rainfall ($r = 0.287$) had non-significant positive correlation with the adult population under SRI method (Table 23).

ii. II year (*Kharif* 2013):

The coefficient correlation data of blue beetle recorded during *Kharif* 2013 (Table 23) revealed that non-significant results. However, maximum temperature ($r = -0.170$), rainfall ($r = -0.414$) and bright sunshine hrs ($r = -0.382$) had positive influence on leaf damage of rice blue beetle, while minimum temperature ($r = 0.092$) and relative humidity ($r = 0.155$) had negative effect under SRI method.

The blue beetle adult population correlation indicated non-significant results with weather parameters. However, maximum temperature ($r = -0.123$), rainfall ($r = -0.403$) and bright sunshine hrs ($r = -0.325$) had negative force, while minimum temperature ($r = 0.029$) and relative humidity ($r = 0.119$) showed positive correlation with the population of rice blue beetle (Table 23).

iii. Pooled:

The pooled result of coefficient correlation presented in Table 23 revealed that the rice blue beetle leaf damage showed significant negative correlation with bright sunshine hrs ($r = -0.485$) only, while maximum temperature ($r = -0.428$) and rainfall ($r = -0.248$) had non-significant negative correlation. However, minimum temperature ($r = 0.214$) and relative humidity ($r = 0.386$) had non-significant positive correlation with the damage of blue beetle in SRI method of planting.

The pooled correlation data of the blue beetle population (Table 23) indicated significant negative effect with bright sunshine hrs ($r = -0.484$) in SRI method. While, maximum temperature ($r = -0.405$) and rainfall ($r = -0.220$) had non-significant negative correlation with the blue beetle population. Minimum temperature ($r = 0.225$) and relative humidity ($r = 0.375$) had non-significant positive influence on the adult population.

The two years data revealed that bright sunshine hrs only control the leaf damage and the population of the rice blue beetle, but caused negative influence. Other weather parameters did not affect blue beetle damage and population, however, maximum temperature and rainfall showed their negative as well as minimum temperature and relative humidity had positive consequence on the leaf damage and the population of the blue beetle under conventional and SRI method.

4.1.2.7 Rice sheath mite (*S. spinkii*)

A. Conventional method:

i. I year (*Kharif* 2012):

The correlation result of first year under conventional method (Table 24) indicated that that maximum temperature ($r = 0.797$) and sunshine hrs ($r = 0.846$) had significant positive correlation with the population of sheath mite, while minimum temperature ($r = -0.753$) and relative humidity ($r = -0.486$) had significant negative correlation with the population. Rainfall ($r = -0.272$) recorded non-significant negative correlation with the population of sheath mite.

ii. II year (*Kharif* 2013):

The results of sheath mite coefficient correlation recorded during *Kharif* 2013 (Table 24) revealed that maximum temperature ($r = 0.488$) and bright sunshine hrs ($r = 0.683$) had significant positive correlation with the population of sheath mite, while relative humidity ($r = -0.491$) had significant negative correlation with the population under conventional method. Minimum temperature ($r = -0.295$) had non-significant negative correlation with the population of sheath mite, whereas, rainfall ($r = 0.345$) showed non-significant positive correlation with the population of sheath mite.

iii. Pooled:

The pooled results of coefficient correlation (Table 24) indicated that the population of sheath mite exhibited significant positive correlation with maximum temperature ($r = 0.712$) and sunshine hrs

($r = 0.787$), while significant negative correlation was observed in minimum temperature ($r = -0.606$) and relative humidity ($r = -0.533$). However, rainfall ($r = 0.201$) showed non-significant positive correlation with the population of sheath mite in conventional method of planting.

Table 24: Correlation of rice sheath mite incidence with weather parameters in conventional and SRI method during *Kharif* 2012 and 2013

Method & Year	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Bright Sunshine hrs
Conventional method (No. of mite/leaf sheath)					
I year (<i>Kharif</i> 2012)	0.797**	-0.753**	-0.486*	-0.272	0.846**
II year (<i>Kharif</i> 2013)	0.488*	-0.295	-0.491*	0.345	0.683**
Pooled	0.712**	-0.606**	-0.533*	0.201	0.787**
SRI method (No. of mite/leaf sheath)					
I year (<i>Kharif</i> 2012)	0.813**	-0.773**	-0.506*	-0.253	0.870**
II year (<i>Kharif</i> 2013)	0.502*	-0.359	-0.545*	0.392	0.689**
Pooled	0.737**	-0.635*	-0.551*	0.254	0.810**
* Significant at 5% level ($r = 0.482$) and ** at 1% level ($r = 0.606$).					

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI method, the findings of correlation (Table 24) showed that maximum temperature ($r = 0.813$) and sunshine hrs ($r = 0.870$) had significant positive correlation with the population of sheath mite, while minimum temperature ($r = -0.773$) and relative humidity ($r = -0.506$) had significant negative correlation with the population. Rainfall ($r = -0.253$) had non-significant negative correlation with the population of mite.

ii. II year (*Kharif* 2013):

The results coefficient correlation of sheath mite population recorded during *kharif* 2013 (Table 24) revealed that maximum temperature ($r = 0.502$) and bright sunshine hrs ($r = 0.689$) had

significant positive correlation, while relative humidity ($r = -0.545$) showed significant negative correlation with the population of sheath mite. However, minimum temperature ($r = -0.359$) had non-significant negative correlation with the population of sheath mite, while rainfall ($r = 0.392$) revealed non-significant positive correlation with the population of mite.

iii. Pooled:

The pooled data of the population of sheath mite coefficient correlation (Table 24) indicated that maximum temperature ($r = 0.737$) and sunshine hrs ($r = 0.810$) had significant positive correlation, while minimum temperature ($r = -0.635$) and relative humidity ($r = -0.551$) had significant negative influence on the population of sheath mite in SRI method. However, rainfall ($r = 0.254$) showed non-significant positive correlation with the population of mite.

The two years data indicated that the maximum temperature and bright sunshine hrs positively affect the population of the rice sheath mite, while minimum temperature and relative humidity showed their negative end result. Rainfall did not showed any major consequence on the population built up of sheath mite. The correlation of sheath mite in rice under conventional and SRI method is not discussed due to want of literature.

4.1.2.8 Spiders:

A. Conventional method:

i. I year (*Kharif* 2012):

The correlation co-efficient study during *Kharif* 2012 (Table 25) indicated that maximum temperature ($r = 0.503$) and bright sunshine hrs ($r = 0.625$) had significant positive relationship with spider population. While, minimum temperature ($r = -0.729$) had significant negative association with the population of spider. Relative humidity ($r = -0.256$) had non-significant negative correlation and rainfall ($r = 0.031$) positive correlation with the population of spider under conventional method.

ii. II year (*Kharif* 2013):

Based on correlation co-efficient of *Kharif* 2013 study (Table 25), it is showed that maximum temperature ($r = 0.536$) and bright sunshine hrs ($r = 0.644$) had significantly positive and relative humidity ($r = -0.507$) showed negative association with the population of spider. However, minimum temperature ($r = -0.312$) had non-significantly negative and rainfall ($r = 0.103$) showed positive correlation relationship with spider population under conventional method of planting.

iii. Pooled:

The pooled results of correlation co-efficient under conventional method of planting presented in Table 25 indicated that maximum temperature ($r = 0.563$) and bright sunshine hrs ($r = 0.653$) had significant positive relationship with spider population, whereas, minimum temperature ($r = -0.601$) had significant negative association under conventional method of planting. While, other weather factors *viz.*, relative humidity ($r = -0.381$) had non-significant negative correlation and rainfall ($r = 0.173$) positive correlation with the population of spider under conventional method.

Moreover, the present results are more or less similar to the findings of Khan and Misra (2003), who reported that the bright sunshine hrs, relative humidity and temperature positively regulated the abundance of spider densities in Eastern Uttar Pradesh. While, Misra *et al.* (2005) observed that the impact of weather parameters in general were found positive except negative influence of rainfall on spider population.

In earlier investigation, some mismatching results are observed in the findings of Kharat (2006) who revealed that the spider population was positive non-significantly correlated with maximum temperature, minimum temperature and sunshine hrs while, rainfall and average relative humidity showed negatively non-significant correlation with spider population. Similarly, Patel (2008) indicated that minimum

temperature, average relative humidity and rainfall had non-significant positive correlation and maximum temperature as well as sunshine hrs had non-significant negative correlation with the spider population in rice field.

While, Sankpal (2011) observed that the spider population exhibited significantly positive correlation with maximum temperature and sunshine hrs and significant negative correlation with evening relative humidity. However, minimum temperature, morning relative humidity and rainfall exhibited negative correlation with the population of predatory spiders. Thus, population of predatory spiders was found to be increased with increasing the incidence of yellow stem borer and leaf folder during the crop period. These correlation reports of spider are in agreement with the present finding.

Table 25: Correlation of spider incidence in rice with weather parameters in conventional and SRI method during *Kharif* 2012 and 2013

Method & Year	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Bright Sunshine hrs.
Conventional method (No. of spider/hill)					
I year (<i>Kharif</i> 2012)	0.503*	-0.729**	-0.256	0.031	0.625**
II year (<i>Kharif</i> 2013)	0.536*	-0.312	-0.507*	0.103	0.644**
Pooled	0.563*	-0.601*	-0.381	0.173	0.653**
SRI method (No. of spider/hill)					
I year (<i>Kharif</i> 2012)	0.493*	-0.721**	-0.243	0.029	0.615**
II year (<i>Kharif</i> 2013)	0.549*	-0.332	-0.502*	0.120	0.665**
Pooled	0.557*	-0.607**	-0.381	0.180	0.653**
* Significant at 5% level ($r = 0.482$) and ** at 1% level ($r = 0.606$).					

B. SRI method:

i. I year (*Kharif* 2012):

Under SRI planting method, the correlation coefficient during *kharif* 2012 (Table 25) revealed that maximum temperature ($r = 0.493$)

and bright sunshine hrs ($r = 0.615$) had significantly positive relationship with spider population. While, minimum temperature ($r = -0.721$) had significant negative impact on spider population. Relative humidity influence ($r = -0.243$) was non-significantly negative correlation and rainfall ($r = 0.029$) showed positive correlation with the population of spider.

ii. II year (*Kharif* 2013):

During *Kharif* 2013 study, the correlation co-efficient (Table 25) showed that maximum temperature ($r = 0.549$) and bright sunshine hrs ($r = 0.665$) had significantly positive impact and relative humidity ($r = -0.502$) indicated negative association with the population of spider. However, minimum temperature ($r = -0.332$) had non-significantly negative and rainfall ($r = 0.120$) showed positive correlation relationship with spider population.

iii. Pooled:

The pooled results of correlation co-efficient of spider with weather parameters (Table 25) in SRI method of planting indicated that maximum temperature ($r = 0.557$) and bright sunshine hrs ($r = 0.653$) had significant positive relationship with spider population, whereas, minimum temperature ($r = -0.607$) had significant negative association. While, relative humidity ($r = -0.381$) had non-significant negative correlation and rainfall ($r = 0.180$) showed positive correlation with the population of spider under SRI method.

The two years data of simple co-efficient correlation indicated that the maximum temperature and bright sunshine hrs positively influence the population of the spider in rice field, while minimum temperature showed their negative impact on population build up. Relative humidity and rainfall did not showed any major significance on the population built up of spider under both the method of planting *i.e.* conventional and SRI.

4.2 Screening of rice varieties against rice pest complex:

Considering the economic importance of major insect pests infesting paddy, eighteen varieties were selected and screened for their reaction against major insect pests under field condition at Wheat Research Station Farm, N.A.U., Bardoli during *Kharif* 2012 and 2013.

4.2.1 Yellow stem borer (*S. incertulas*):

The incidence of *S. incertulas* was recorded at 30 and 50 days after transplanting (DAT) for number of dead hearts and 15 days before harvesting (DBH) at heading stage for number of white earheads. The data thus obtained are analyzed and presented in Table 26 to 31 and depicted in Fig. 17 to 19. An attempt was made to categorize the paddy genotypes under test into six categories of resistance *viz*; highly resistant (HS), resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S) and highly susceptible (HS) (Anonymous, 1996^b).

i. 1 year (*Kharif* 2012):

a. Dead hearts at 30 DAT: The data (Table 26 and Fig. 17) on per cent dead hearts due to *S. incertulas* after 30 days of transplanting recorded significant results and revealed that the infestation of the pest in different varieties was varied from 0.28 to 4.85% wherein none of the genotype was found to be free from infestation. From the varieties screened, significantly lowest infestation was registered in genotype GR-103 (0.28%), which was at par with Gurjari (0.37%) and Masuri (0.39%). Similarly, genotypes GNR-3 also registered significantly lower infestation of 0.61% than susceptible check GR-11 and also found at par with GNR-2 (0.74%), Jaya (0.74%), IR-22 (0.78%) and GAR-2 (0.82%). Later on, GAR-1 (1.10%) was less effective genotype, but it was at par with GR-7 (1.15%), NAUR-1 (1.19%), IR-28 (1.26%) and Narmada (1.34%). GR-102 was also less effective (1.64%) amongst above other genotypes, followed by GR-104 (2.03%) and GR-101 (2.10%) and both were at par with each other. The paddy variety GR-12 (3.07%) and GR-11 registered highest (4.85 %) infestation due to *S. incertulas*.

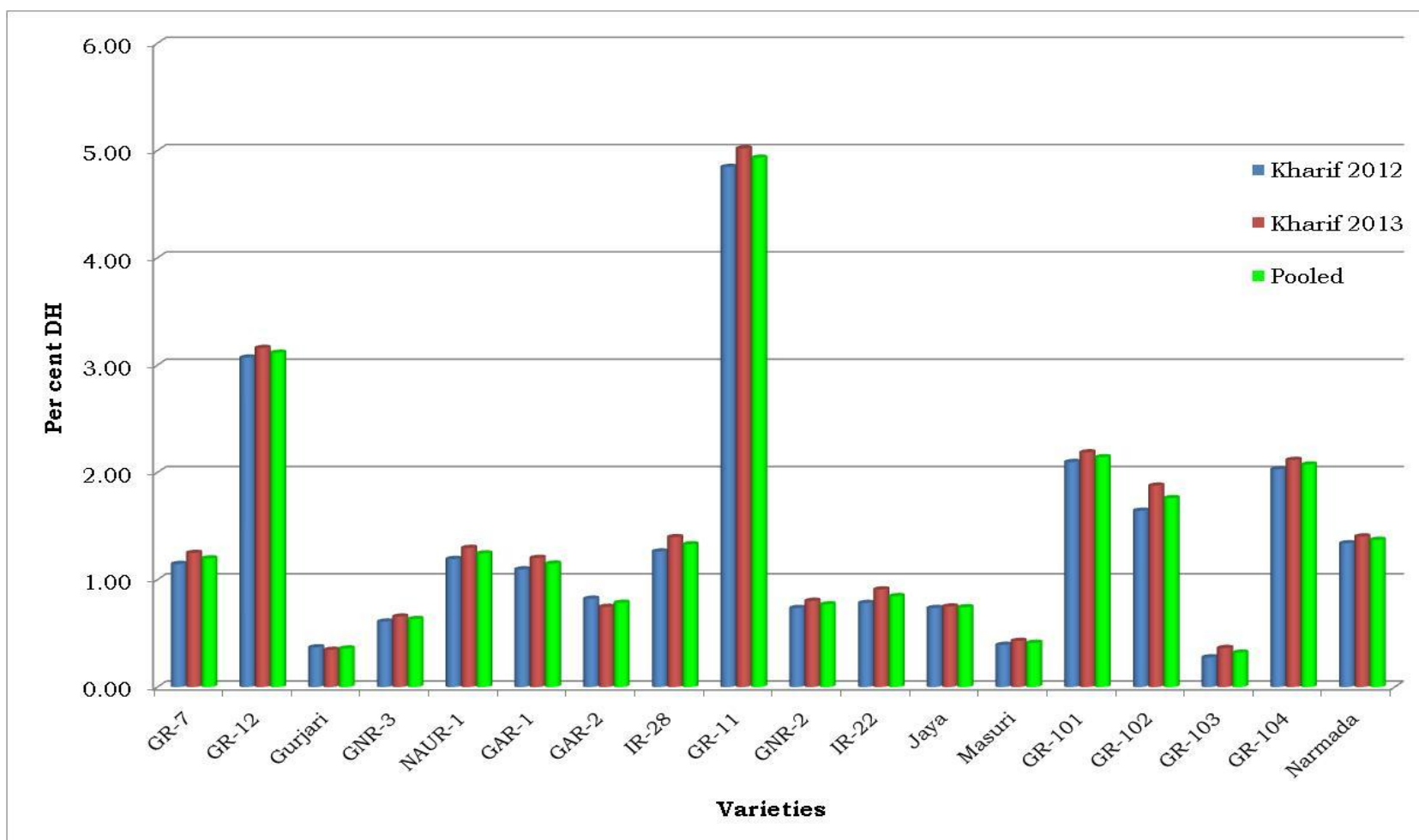


Fig. 17: Varietal screening of rice against yellow stem borer at vegetative stage (30 DAT)

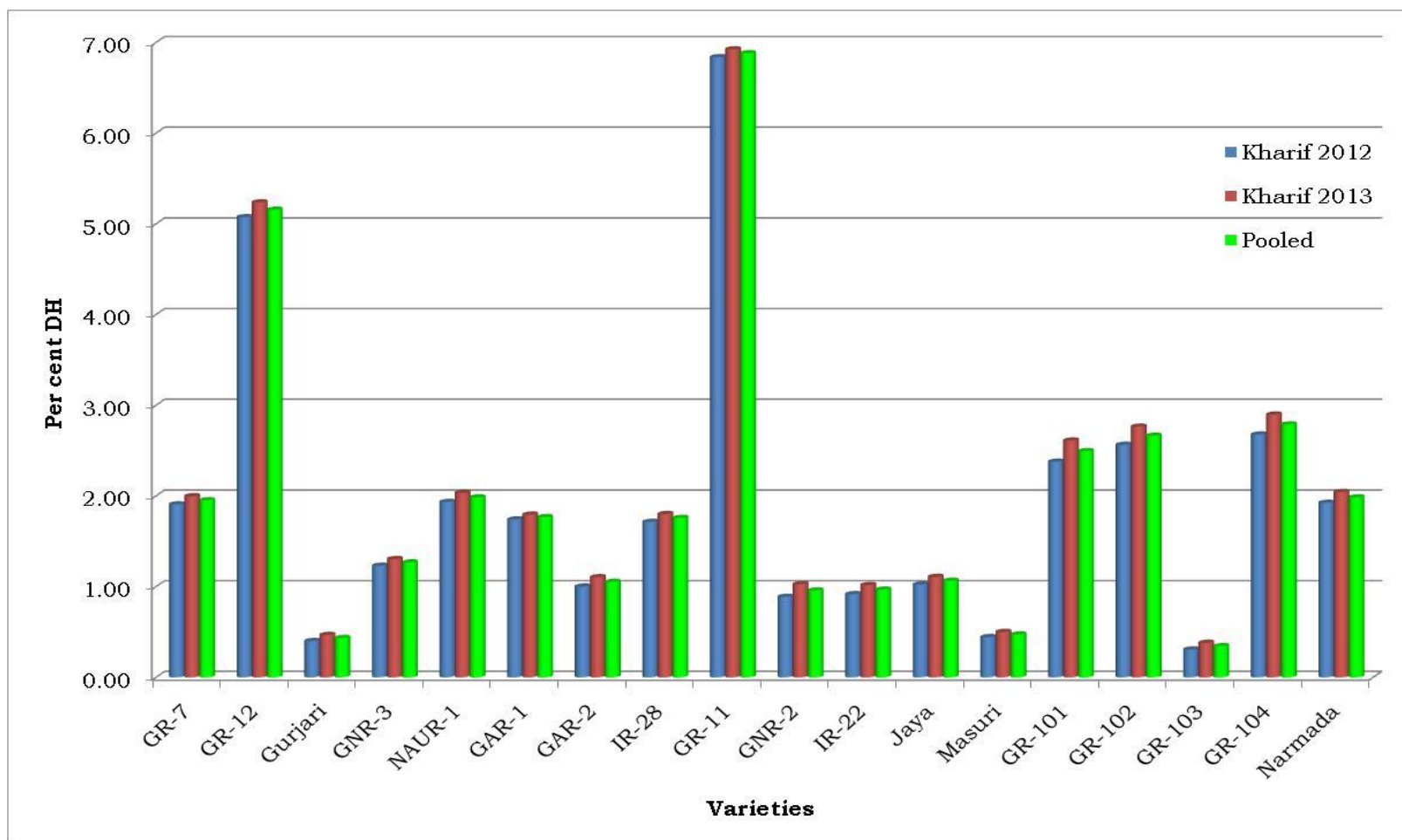


Fig. 18: Varietal screening of rice against yellow stem borer at vegetative stage (50 DAT)

b. Dead hearts at 50 DAT: The first year data (Table 26 and Fig. 18) on per cent dead hearts after 50 days of transplanting showed the significant findings and the infestation in different varieties was varied from 0.31 to 6.84%. Out of the screened varieties, lowest infestation was recorded in variety GR-103 (0.31%), which was at par with Gurjari (0.40%) and Masuri (0.44%). Similarly, variety GNR-2 registered lowest (0.89%) infestation, but was at par with IR-22 (0.92%), GAR-2 (1.00%), Jaya (1.02%) and GNR-3 (1.23%). Same way, variety IR-28 registered lower 1.71% infestation, which was comparable with GAR-1 (1.74%), GR-7 (1.91%), Narmada (1.92%) and NAUR-1 (1.93%). The other variety which recorded slightly higher damage was GR-101 (2.38%), but at par with GR-102 (2.56%) and GR-104 (2.68%). Significantly higher (6.84%) infestation of yellow stem borer was recorded in the variety GR-11 and GR-12 (5.07%).

c. White earhead at heading stage: The first year data of *Kharif* 2012 (Table 27 and Fig. 19) on performance of varieties at heading stage revealed that the infestation of pest varied from 0.07 to 1.96 per cent and none of the varieties was free from infestation. At 15 days before harvesting, variety Masuri showed least (0.07%) white earhead infestation due to yellow stem borer, but it was at par with variety GR-103 (0.08%) and Gurjari (0.09%). The next less susceptible variety was GNR-2 with 0.14% damage and found at par with IR-22 (0.15%), GAR-2 (0.16%), GAR-3 (0.17%) and Jaya (0.18%). The varieties GAR-1 (0.25%) registered moderate infestation due to yellow stem borer, but at par with Narmada (0.26%), IR-28 (0.26%), GR-7 (0.26%), and NAUR-1 (0.27%). The other variety which recorded slightly higher white earhead damage was GR-104 (0.34%), but showed comparable results with GR-102 (0.38%) and GR-101 (0.42%), followed by GR-12 (0.71%). Significantly highest infestation was recorded from susceptible check variety GR-11 (1.96 %).

Table 27: Varietal screening of rice against yellow stem borer at heading stage during Kharif 2012

Sr. No.	Varieties	At heading stage			
		% WEH	Corrected % damage	Scale	Reaction
A.	Early Varieties				
1.	GR-7	2.94 (0.26)	13.41	5	MS
2.	GR-12	4.79 (0.71)	35.99	9	HS
3.	Gurjari	1.68 (0.09)	4.41	1	R
4.	GNR-3	2.35 (0.17)	8.66	3	MR
5.	NAUR-1	2.97 (0.27)	13.75	5	MS
6.	GAR-1	2.84 (0.25)	12.56	5	MS
7.	GAR-2	2.30 (0.16)	8.32	3	MR
8.	IR-28	2.93 (0.26)	13.41	5	MS
B.	Mid-late varieties				
9.	GR-11 (Sus. check)	8.05 (1.96)	--	9	HS
10.	GNR-2	2.15 (0.14)	7.30	3	MR
11.	IR-22	2.22 (0.15)	7.81	3	MR
12.	Jaya	2.45 (0.18)	9.34	3	MR
C.	Late varieties				
13.	Masuri	1.54 (0.07)	3.74	1	R
14.	GR-101	3.69 (0.42)	21.22	7	S
15.	GR-102	3.51 (0.38)	19.19	7	S
16.	GR-103	1.61 (0.08)	4.07	1	R
17.	GR-104	3.34 (0.34)	17.32	7	S
18.	Narmada	2.90 (0.26)	13.07	5	MS
S. E. (m) <u>+</u>		0.16			
C. D. at 5%		0.47			
C. V.%		9.47			
* Values in outside the parentheses are arc sine transformed values and inside are original values.					

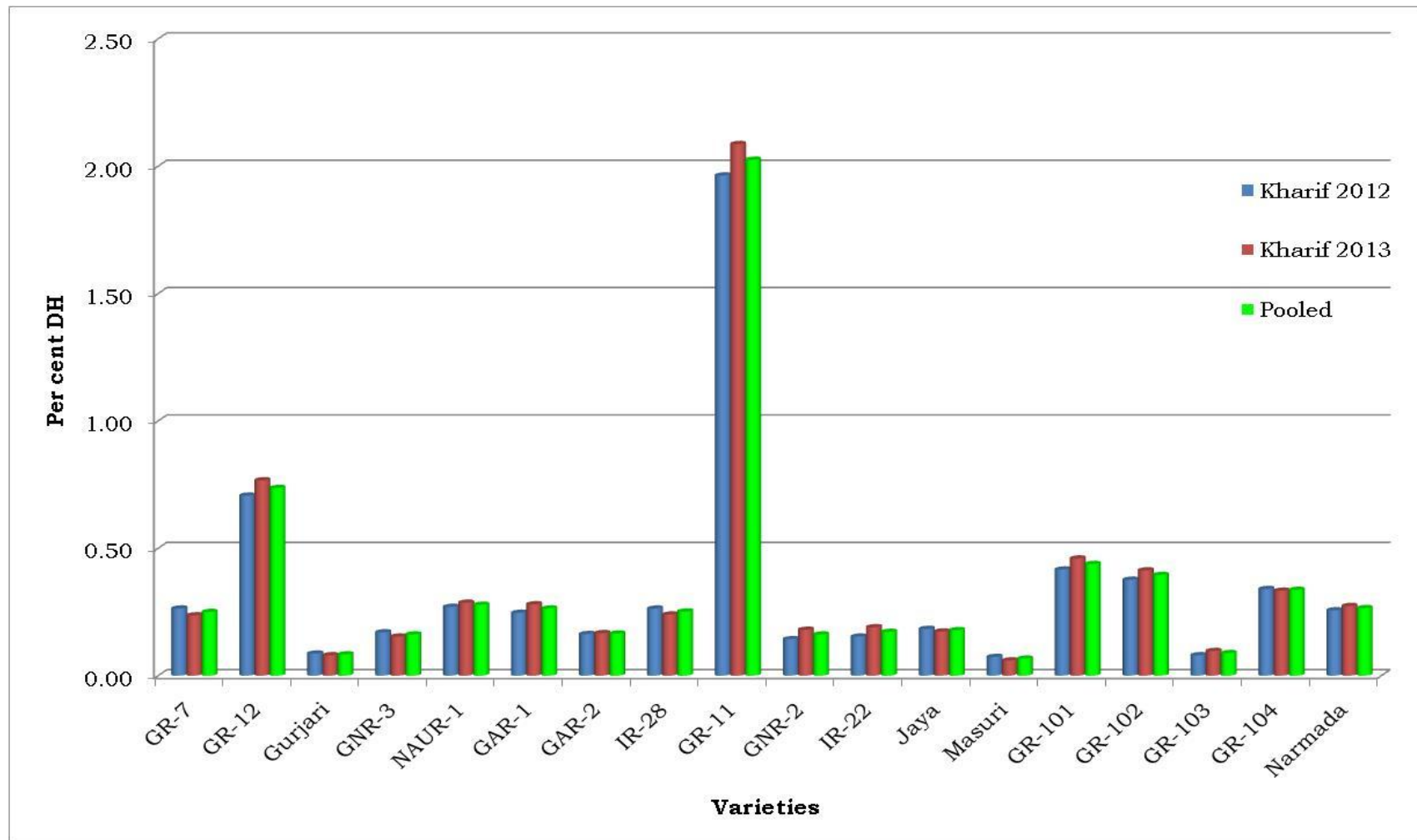


Fig. 19: Varietal screening of rice against yellow stem borer at heading stage

ii. II year (*Kharif* 2013):

a. Dead hearts at 30 DAT: The per cent dead hearts data of second year (Table 28 and Fig. 17) after 30 days of transplanting revealed that the infestation of *S. incertulas* recorded significant results in different varieties varied from 0.35 to 5.02%, wherein none of the varieties was found to be free from infestation. From the varieties screened, significantly lowest infestation was registered in variety Gurjari (0.35%) and was at par with GR-103 (0.36%) and Masuri (0.43%). Similarly, variety GNR-3 also registered significantly lower dead heart infestation of 0.66% than susceptible check GR-11 and also found at par with GAR-2 (0.75%), Jaya (0.75%), GNR-2 (0.80%) and IR-22 (0.91%). Further, GAR-1 (1.20%) was found moderately susceptible and was at par with GR-7 (1.25%), NAUR-1 (1.30%), IR-28 (1.40%) and Narmada (1.40%). Variety GR-102 was less effective (1.88%) amongst earlier varieties, but was at par with GR-104 (2.12%) and GR-101 (2.19%). The paddy variety GR-12 (3.16%) and GR-11 registered highest (5.02 %) dead heart infestation due to *S. incertulas*.

b. Dead hearts at 50 DAT: The second year data of *Kharif* 2013 (Table 28 and Fig. 18) on per cent dead hearts after 50 days of transplanting showed significant findings in different varieties, which was varied from 0.38 to 6.92% dead heart. Out of the screened varieties, lowest per cent dead hearts was recorded in variety GR-103 (0.38%) and it was at par with Gurjari (0.47%) and Masuri (0.50%). Further, variety IR-22 registered lowest (1.02%) infestation, but was comparable with GNR-2 (1.03%), GAR-2 (1.10%), Jaya (1.11%) and GNR-3 (1.30%). Same way, variety GAR-1 registered lower 1.79% infestation, which was at par with IR-28 (1.80%), GR-7 (2.00%), NAUR-1 (2.03%) and Narmada (2.04%). The other variety which recorded slightly higher per cent dead heart was GR-101 (2.61%) and showed comparable results with GR-102 (2.76%) and GR-104 (2.90%). Significantly higher 5.24 and 6.92% per cent dead heart was recorded in the variety GR-12 and variety GR-11, respectively.

Table 28: Varietal screening of rice against yellow stem borer at vegetative stage during *Kharif* 2013

[illegible]

Table 29: Varietal screening of rice against yellow stem borer at heading stage during Kharif 2013

Sr. No.	Varieties	At heading stage			
		% WEH	Corrected % damage	Scale	Reaction
A.	Early Varieties				
1.	GR-7	2.78 (0.24)	12.35	5	MS
2.	GR-12	4.98 (0.77)	36.38	9	HS
3.	Gurjari	1.60 (0.08)	4.12	1	R
4.	GNR-3	2.24 (0.15)	7.98	3	MR
5.	NAUR-1	3.06 (0.29)	13.74	5	MS
6.	GAR-1	3.02 (0.28)	13.00	5	MS
7.	GAR-2	2.33 (0.17)	8.15	3	MR
8.	IR-28	2.80 (0.24)	12.43	5	MS
B.	Mid-late varieties				
9.	GR-11 (Sus. check)	8.30 (2.09)	--	9	HS
10.	GNR-2	2.43 (0.18)	7.98	3	MR
11.	IR-22	2.50 (0.19)	8.48	3	MR
12.	Jaya	2.39 (0.17)	8.81	3	MR
C.	Late varieties				
13.	Masuri	1.39 (0.06)	3.29	1	R
14.	GR-101	3.88 (0.46)	21.65	7	S
15.	GR-102	3.67 (0.41)	19.51	7	S
16.	GR-103	1.78 (0.10)	4.36	1	R
17.	GR-104	3.31 (0.33)	16.63	7	S
18.	Narmada	2.98 (0.27)	13.09	5	MS
S. E. (m)		0.18			
C. D. at 5%		0.51			
C. V.%		10.02			
* Values in outside the parentheses are arc sine transformed values and inside are original values.					

c. White earhead at heading stage: The second year data (Table 29 and Fig. 19) on performance of varieties at heading stage was found significant and indicated that the infestation of pest varied from 0.06 to 2.09 per cent and none of the variety was free from infestation. At 15 days before harvesting, variety Masuri showed least (0.06%) infestation due to yellow stem borer, but it was at par with Gurjari (0.08%) and GR-103 (0.10%). The next less susceptible variety was GNR-3 with 0.15% damage and found at par with GAR-2 (0.17%), Jaya (0.17%), GNR-2 (0.18%) and IR-22 (0.19%). The variety GR-7 (0.24%) registered moderate infestation due to yellow stem borer, but was found at par with IR-28 (0.24%), Narmada (0.27%), GAR-1 (0.28%) and NAUR-1 (0.29%). The other varieties which recorded slightly higher damage was GR-104 (0.33%) and comparable with GR-102 (0.41%), followed by GR-101 (0.46%) and GR-12 (0.77%). Significantly highest infestation was recorded from susceptible check GR-11 (2.09 %).

iii. Pooled:

a. Dead hearts at 30 DAT: The pooled data (Table 30 and Fig. 17) on per cent dead hearts due to *S. incertulas* after 30 days of transplanting found significant, which revealed that the infestation of the pest in different varieties was varied from 0.32 to 4.93% and none of the genotype was found to be free from infestation. From the varieties screened, the lowest infestation was registered in variety GR-103 (0.32%) and was at par with Gurjari (0.36%) and Masuri (0.41%). Similarly, variety GNR-3 also registered the lower infestation of 0.63% than susceptible check GR-11 and also found at par with Jaya (0.74%), GNR-2 (0.77%) and GAR-2 (0.79%). Further, IR-22 recorded significantly moderate dead heart (0.85%), followed by GAR-1 (1.15%) and it was at par with GR-7 (1.20%), NAUR-1 (1.25%), IR-28 (1.33%). Amongst other varieties, Narmada (1.37%) and GR-102 (1.76%) were less effective, followed by GR-104 (2.07%), but was at par with GR-101 (2.14%). The paddy variety GR-12 (3.12%) and GR-11 registered highest (4.93%) infestation of *S. incertulas*. The interaction effect between varieties and

year was non-significant, which revealed consistent performance of different varieties during the period of both years.

b. Dead hearts at 50 DAT: The pooled data (Table 30 and Fig. 18) on per cent dead hearts after 50 days of transplanting showed significant values in different varieties, which was varied from 0.34 to 6.88 per cent. Out of the screened varieties after 50 days of transplanting, the lowest infestation was recorded in variety GR-103 (0.34%) and it was at par with Gurjari (0.43%) and Masuri (0.47%). Correspondingly, the variety GNR-2 registered lower (0.96%) infestation, but was at par with IR-22 (0.97%), GAR-2 (1.05%) and Jaya (1.07%). The variety GNR-3 registered significantly lower (1.27%) infestation, followed by IR-28 (1.76%), which was at par with GAR-1 (1.77%), GR-7 (1.95%), Narmada (1.98%) and NAUR-1 (1.98%). The next variety which recorded slightly higher damage was GR-101 (2.49%), but was at par with GR-102 (2.66%) and GR-104 (2.79%). Significantly higher (5.16%) infestation was recorded in the variety GR-12 and variety GR-11 (6.88%). The interaction effect between varieties and year was found non-significant, which revealed consistent performance of different varieties during the period of both years.

Looking to the score of infestation (per cent dead hearts), the varieties GR-103, Gurjari and Masuri were found resistant (R) as these varieties registered DH index in between 1 to 10 per cent (Scale 1), whereas five varieties *viz.* GNR-2, IR-22, Jaya, GNR-3 and GAR-2 were graded as moderately resistant (MR) in a Scale of 3 to stem borer as they exhibited the DH index between 11 and 20 per cent (Table 30). Another five varieties *viz.* GAR-1, GR-7, NAUR-1, IR-28 and Narmada showed DH index between 21 to 30 per cent were categories in moderately susceptible (MS) with Scale of 5. Remaining varieties *i.e.* GR-102, GR-104 and GR-101 were graded as susceptible (S) found in Scale 7 against yellow stem borer DH index within 31 to 60%. GR-12 and GR-11 variety proved as highly susceptible (HS) at vegetative stage and scored the DH index of more than 60 per cent (Scale 9).

Table 30: Varietal screening of rice against yellow stem borer at vegetative stage (Two years pooled)

[illegible]

In earlier studies, Singh and Pandey (1997) found that none of the cultivar showed great resistance to *S. incertulus* at vegetative stage. As per the findings of Korat *et al.* (1998) from Gujarat, minimum per cent tiller damage by stem borer was observed in Masuri, Narmada and GR-101 as against high tiller damage in GR-11, which match with the present results.

According to Korat *et al.* (2003^b), out of six rice cultures and two varieties (Jaya and GR-11) tested for their reaction to pests, culture IET-12537, IET14074 and RP-3179-1462 were found free from stem borer attack. As per data of Sankpal (2011), the variety GR-11 exhibited significantly highest dead hearts due to *S. incertulas*, followed by variety GR-4 and GR-12. These finding confirms the present results. Similar data was also reported by Gole (2012) showed that the genotypes Gurjari were found moderately resistant, whereas variety GR-11 proved as highly susceptible at vegetative stage. While at 50 DAT, dead heart index of Gurjari categorized it as moderately resistant and variety GR-11 was highly susceptible to yellow stem borer.

c. White earhead at heading stage: The pooled data (Table 31 and Fig. 19) on performance of varieties at heading stage revealed significant findings on white earhead infestation of yellow stem borer, which was varied from 0.07 to 2.03 per cent and none of the variety was free from infestation. At 15 days before harvesting, variety Masuri showed least (0.07%) white earhead due to yellow stem borer, but it was comparable and at par with variety Gurjari (0.08%) and GR-103 (0.09%). The next less susceptible variety was GNR-2 with 0.16% damage and found at par with GAR-3 (0.16%), GAR-2 (0.17%), IR-22 (0.17%) and Jaya (0.18%). The variety GR-7 (0.25%) registered moderate white earhead infestation due to yellow stem borer, but found at par with IR-28 (0.25%), GAR-1 (0.26%), Narmada (0.27%) and NAUR-1 (0.28%). The other varieties which recorded slightly higher damage was GR-104 (0.34%) and GR-102 (0.40%) and found at par with each other, followed by GR-101 (0.44%). Significantly highest infestation was recorded from variety GR-11 (2.03

%) and GR-12 (0.74%). Regarding the interaction effect between varieties and year, the results were non-significant indicating consistent performance of different varieties.

The score of yellow stem borer white earhead per cent infestation (Table 31) of the varieties *viz.*, Masuri, Gurjari and GR-103 were showed resistant (R) category as these varieties registered DH index in between 1 to 5% (Scale 1). While, five varieties *viz.* GNR-2, GNR-3, GAR-2, IR-22 and Jaya were graded as moderately resistant (MR) to stem borer in Scale 3 as they exhibited the DH index between 6 and 10%. Another five varieties *viz.* GR-7, IR-28, GAR-1, Narmada and NAUR-1 were showed DH index between 11 to 15% (Scale 5) in moderately susceptible (MS) category. Remaining varieties *i.e.* GR-104, GR-102 and GR-101 were graded as susceptible (S) in Scale 7 against yellow stem borer DH index within 16 to 25%. Variety GR-12 and GR-11 proved as highly susceptible (HS) to yellow stem borer at heading stage and scored the DH index of more than 26% (Scale 9).

In previous findings, Singh and Pandey (1997) observed at heading stage that the cultivar IR-72 was found resistant and IR-36 and Ratna were moderately resistant to *S. incertulus*. While, Dash *et al.* (2007) recorded the lowest white earhead value in Surendra Hybrid rice H6201 supported highest white earhead than Jaya. These studies support the present results. However, similar type of trend is given by Sankpal (2011), who observed highest infestation from susceptible check variety GR-11, followed by variety GR-4 and GR-12 at 15 days before harvesting.

Likewise, Gole (2012) showed that at heading stage, the genotypes/varieties NWGR-6050, NWGR-7078 and Gurjari were categorized as moderately resistant, whereas variety GR-11 was found to be highly susceptible at every stage of the crop showing maximum white earheads damage. These findings of earlier workers match with the current situation.

Table 31: Varietal screening of rice against yellow stem borer heading stage (Two years pooled)

Sr. No.	Varieties	At heading stage			
		% WEH	Corrected % damage	Scale	Reaction
A.	Early Varieties				
1.	GR-7	2.86 (0.25)	12.35	5	MS
2.	GR-12	4.89 (0.74)	36.38	9	HS
3.	Gurjari	1.64 (0.08)	4.12	1	R
4.	GNR-3	2.29 (0.16)	7.98	3	MR
5.	NAUR-1	3.02 (0.28)	13.74	5	MS
6.	GAR-1	2.93 (0.26)	13.00	5	MS
7.	GAR-2	2.31 (0.17)	8.15	3	MR
8.	IR-28	2.87 (0.25)	12.43	5	MS
B.	Mid-late varieties				
9.	GR-11 (Sus. check)	8.18 (2.03)	--	9	HS
10.	GNR-2	2.29 (0.16)	7.98	3	MR
11.	IR-22	2.36 (0.17)	8.48	3	MR
12.	Jaya	2.42 (0.18)	8.81	3	MR
C.	Late varieties				
13.	Masuri	1.46 (0.07)	3.29	1	R
14.	GR-101	3.79 (0.44)	21.65	7	S
15.	GR-102	3.59 (0.40)	19.51	7	S
16.	GR-103	1.70 (0.09)	4.36	1	R
17.	GR-104	3.32 (0.34)	16.63	7	S
18.	Narmada	2.94 (0.27)	13.09	5	MS
S. E. (m)+ (T)		0.11			
C. D. at 5% (T)		0.32			
S. E. (m)+ (YxT)		0.17			
C. D. at 5% (YxT)		NS			
C. V. %		7.78			
* Values in outside the parentheses are arc sine transformed values and inside are original values.					

4.2.2 Green leafhopper (*N. virescens*):

The data on per cent hill damaged due to green leaf hopper is presented in Table 32 and 33 as well as depicted in Fig. 20. The findings indicated that all varieties showed more or less per cent hill damage.

i. I year (*Kharif* 2012):

Out of the eighteen varieties evaluated against *N. virescens*, the results revealed that none of the variety was free from the attack of green leafhopper and the difference in hill damage in different varieties was found significant (Table 32 and Fig. 20). The variety GR-104 was found less susceptible due to the low hill damage (0.13%) and found at par with GR-102 (0.18%), GR-101 (0.20%) and GR-102 (0.22%). The variety GNR-2 reported 0.55% hill infestation and was comparable with GAR-1 (0.57%), Narmada (0.59%) and GR-7 (0.63%). The other varieties NAUR-1, GNR-3, and GAR-2 exhibited 0.87, 0.88 and 0.93 per cent hill damage and found at par with each other. The moderately higher hill damage due to green leafhopper was registered in variety IR-22 (1.13%) and GR-12 (1.19%) than all the evaluated varieties of paddy. The next varieties reporting higher hill damage were IR-28, GR-11 and Masuri which recorded 1.68, 1.72 and 1.88%, respectively and were at par with each other. Significantly highest hill damage was found in variety Gurjari and Jaya with 2.23 and 2.77% infestation.

ii. II year (*Kharif* 2013):

During 2013-14 also, same 18 varieties were evaluated against *N. virescens* (Table 32 and Fig. 20) and the difference in hill damage in different varieties was found significant. The variety GR-104 was found more resistant due to the low hill damage (0.17%), but showed at par results with GR-103 (0.21%), GR-102 (0.25%) and GR-101 (0.27%). The variety GNR-2 reported 0.53% hill damage and at par with GR-7 (0.59%), Narmada (0.60%) and GAR-1 (0.61%). The varieties *viz.*, NAUR-1, GAR-2, GNR-3, IR-22 and GR-12 exhibited 0.95, 1.01, 1.04, 1.16 and 1.16% hill damage and found at par with each other. The higher hill damage due to

green leafhopper was registered in variety IR-28 (1.76%), which was at par with GR-11 and Masuri and showed 1.82 and 1.86% infestation, respectively. The significantly highest hill damage was found in variety Gurjari and Jaya with 2.32 and 2.85% hill damage, respectively.

Table 32: Varietal screening of rice against green leafhopper during *Kharif* 2012 and 2013

[illegible]

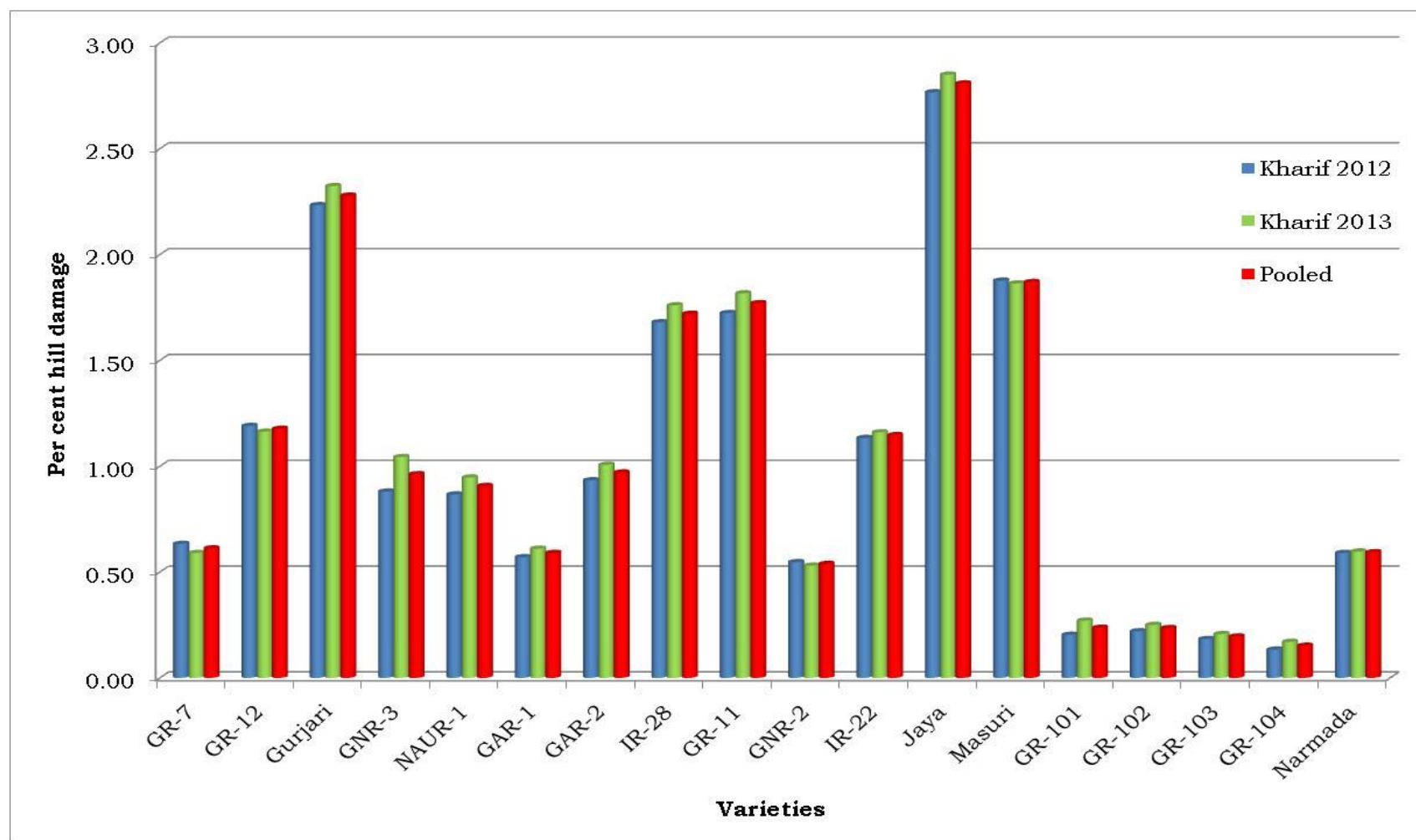


Fig. 20: Varietal screening of rice against green leafhopper

iii. Pooled:

The pooled data on evaluation of 18 varieties against *N. virescens* revealed the significant difference in hill damage in varieties (Table 33 and Fig. 20), where the variety GR-104 showed significantly low hill damage (0.15%). In susceptibility order, GR-103 (0.20%), GR-102 (0.24%) and GR-101 (0.24%) were also recorded less susceptibility and found at par with each other. The next variety GNR-2 reported moderate 0.54% hill infestation and was found at par with GAR-1 (0.59%), Narmada (0.59%), while GR-7 showed significantly moderate hill damage (0.61%). The other varieties viz., NAUR-1, GNR-3 and GAR-2 exhibited 0.91, 0.96 and 0.97 per cent hill damage and found at par with each other. The moderately higher hill damage due to green leafhopper was registered in variety IR-22 (1.15%) and GR-12 (1.18%) than other evaluated varieties of paddy. The next varieties reporting higher hill damage were IR-28 and GR-11 recorded 1.72 and 1.87%, respectively and were at par with each other. Significantly highest hill damage was found in variety Masuri, Gurjari and Jaya with 1.87, 2.28 and 2.81% infestation, respectively. The interaction effect between varieties and two year was non-significant revealed consistent performance of varieties.

On corrected mortality index basis (Table 33), GR-101, GR-102, GR-103, and GR-104 grouped into resistant (scale 1) and recorded hill damage between 1 to 10%. While, GNR-2, GAR-1, Narmada and GR-7 and were categories into moderately resistant (scale 3) with hill damage between 11 to 25%. Other varieties viz., NAUR-1, GNR-3, GAR-2, IR-22 and GR-12 were found moderately susceptible reaction (scale 5) and showed hill damage between 26 to 50%. The variety IR-28, GR-11 and Masuri were recorded susceptible (scale 7) with hill damage between 51 to 75%, whereas, Gurjari and Jaya were grouped into the highly susceptible category (scale 9) and showed hill damage from 76 to 100%.

The present was supported by the finding of Garg (1997) who reported the greatest population on the most susceptible variety T(N)1, followed by Ratna, Jaya, IR-20, Mudgo and Vijaya.

Table 33: Varietal screening of rice against green leafhopper (Two years pooled)

Sr. No.	Varieties	% hill damage	Corrected % damage	Scale	Reaction
A.	Early Varieties				
1.	GR-7	4.47 (0.61)	21.78	3	MR
2.	GR-12	6.22 (1.18)	41.90	5	MS
3.	Gurjari	8.68 (2.28)	81.13	9	HS
4.	GNR-3	5.61 (0.96)	34.24	5	MS
5.	NAUR-1	5.44 (0.91)	32.28	5	MS
6.	GAR-1	4.39 (0.59)	21.01	3	MR
7.	GAR-2	5.63 (0.97)	34.54	5	MS
8.	IR-28	7.53 (1.72)	61.25	7	S
B.	Mid-late varieties				
9.	GR-11	7.64 (1.77)	63.03	7	S
10.	GNR-2	4.19 (0.54)	19.17	3	MR
11.	IR-22	6.14 (1.15)	40.83	5	MS
12.	Jaya (Sus. check)	9.65 (2.81)	--	9	HS
C.	Late varieties				
13.	Masuri	7.85 (1.87)	66.59	7	S
14.	GR-101	2.77 (0.24)	8.43	1	R
15.	GR-102	2.77 (0.24)	8.37	1	R
16.	GR-103	2.52 (0.20)	6.94	1	R
17.	GR-104	2.21 (0.15)	5.40	1	R
18.	Narmada	4.39 (0.59)	21.13	3	MR
S. E. (m) ₊ (T)		0.17			
C. D. at 5% (T)		0.26			
S. E. (m) ₊ (YxT)		0.26			
C. D. at 5% (YxT)		NS			
C. V.%		8.38			
* Values in outside the parentheses are arc sine transformed values and inside are original values.					

4.2.3 Brown plant hopper (*N. lugens*):

The data on per cent hill damage due to brown plant hopper indicated that none of the variety was free from the attack of *N. lugens* and all varieties showed more or less per cent damaged hills of rice brown plant hopper (Table 34-35 and Fig. 21).

i. I year (*Kharif* 2012):

The findings of first year varietal screening revealed significant the results on hill damage in eighteen varieties (Table 34 and Fig. 21). Out of the eighteen varieties, GR-104 (0.08%) and GR-103 (0.13%) was found less susceptible due to the low hill damage and at par each other. While, the variety GR-102 and GR-101 also reported less susceptibility with 0.18 and 0.21% hill damage, respectively and were at par with other. The varieties *viz.*, GNR-3 and GNR-2 showed 0.35 and 0.49% hill damage and at par with each other, followed by Narmada (0.52%), GAR-1 (0.54%) and GR-7 (0.58%). The varieties NAUR-1 (0.79%), GAR-2 (0.80%), IR-22 (1.07%) and GR-12 (1.13%) exhibited moderate resistant to hill damage, in which earlier two and later two found at par with each other. The higher hill damage of *N. lugens* was registered in variety IR-28 (1.62%) than all the evaluated varieties of paddy and showed at par results with GR-11 (1.67%) and Masuri (1.79%). The significantly highest hill damage was found in variety Gurjari and Jaya with 2.17 and 2.64% hill infestation, respectively.

ii. II year (*Kharif* 2013):

During *Kharif* 2013, same 18 varieties were evaluated against brown plant hopper (Table 34 and Fig. 21) and the results of hill damage were found significant. The findings revealed that variety GR-104 was recorded less susceptibility to hill damage (0.10%), but showed at par results with GR-103 (0.15%), GR-102 (0.21%), while GR-101 recorded significantly less susceptible infestation due to low hill damage of 0.24%. The variety GNR-3 reported 0.47% hill damage and at par with GNR-2 (0.51%), GAR-1 (0.57%), Narmada (0.58%) and GR-7 (0.64%).

Table 34: Varietal screening of rice against Brown plant hopper during Kharif 2012 and 2013

Sr. No.	Varieties	Kharif 2012				Kharif 2013			
		% hill damage	Corr. % damage	Scale	Reaction	% hill damage	Corr. % damage	Scale	Reaction
A.	Early Varieties								
1.	GR-7	4.36 (0.58)	21.97	3	MR	4.58 (0.64)	21.69	3	MR
2.	GR-12	6.10 (1.13)	42.93	5	MS	6.38 (1.24)	41.92	5	MS
3.	Gurjari	8.47 (2.17)	82.32	9	HS	8.91 (2.40)	81.47	9	HS
4.	GNR-3	3.35 (0.35)	13.13	3	MR	3.84 (0.47)	15.82	3	MR
5.	NAUR-1	5.08 (0.79)	29.80	5	MS	5.42 (0.90)	30.40	5	MS
6.	GAR-1	4.20 (0.54)	20.45	3	MR	4.29 (0.57)	19.21	3	MR
7.	GAR-2	5.13 (0.80)	30.30	5	MS	5.51 (0.93)	31.41	5	MS
8.	IR-28	7.30 (1.62)	61.24	7	S	7.71 (1.81)	61.24	7	S
B.	Mid-late varieties								
9.	GR-11	7.42 (1.67)	63.26	7	S	7.78 (1.84)	62.37	7	S
10.	GNR-2	3.99 (0.49)	18.43	3	MR	4.03 (0.51)	17.18	3	MR
11.	IR-22	5.92 (1.07)	40.53	5	MS	6.35 (1.23)	41.69	5	MS
12.	Jaya (Sus. check)	9.35 (2.64)	--	9	HS	9.89 (2.95)	--	9	HS
C.	Late varieties								
13.	Masuri	7.68 (1.79)	67.80	7	S	7.79 (1.85)	62.60	7	S
14.	GR-101	2.59 (0.21)	7.83	1	R	2.78 (0.24)	8.02	1	R
15.	GR-102	2.44 (0.18)	6.94	1	R	2.60 (0.21)	7.01	1	R
16.	GR-103	2.08 (0.13)	5.05	1	R	2.22 (0.15)	5.08	1	R
17.	GR-104	1.60 (0.08)	3.03	1	R	1.81 (0.10)	3.39	1	R
18.	Narmada	4.08 (0.52)	19.70	3	MR	4.30 (0.58)	19.55	3	MR
S. E. (m)		0.24				0.29			
C. D. at 5%		0.69				0.84			
C. V.		8.17				9.42			

* Values in outside the parentheses are arc sine transformed values and inside are original values.

The next less susceptible varieties were NAUR-1, GAR-2, IR-22 and GR-12 exhibited 0.90, 0.93, 1.23, and 1.24% hill damage, in which former two and later two found at par with each other. The higher hill

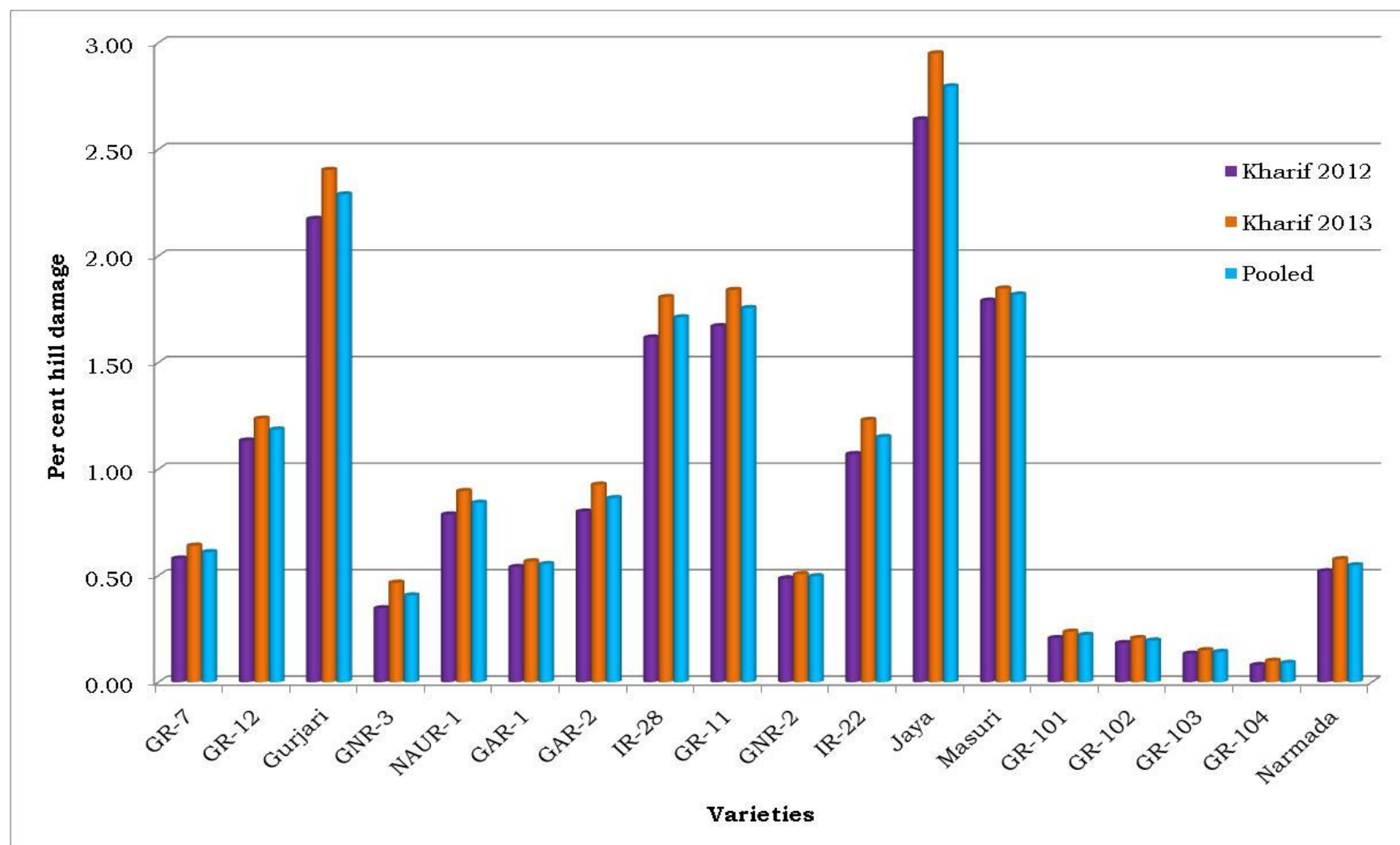


Fig. 21: Varietal screening of rice against brown plant hopper

infestation of *N. lugens* was registered in variety IR-28 (1.81%) and at par with GR-11 and Masuri, which showed 1.84 and 1.85% hill infestation, respectively. The significantly highest hill damage was found in variety Gurjari and Jaya with 2.40 and 2.95% hill damage, respectively.

iii. Pooled:

The pooled data (Table 35 and Fig. 21) revealed that the minimum per cent damaged hills was found in variety GR-104 (0.09%) and GR-103 (0.14%), which were at par with each other. This was followed by GR-102, GR-101, GNR-3 and GNR-2 with 0.20, 0.22, 0.41 and 0.50 per cent damaged hills, respectively in which former two and later two found at par with each other. The other varieties like Narmada, GAR-1 and GR-7 having 0.55, 0.55 and 0.61 per cent damaged hills, respectively and were at par with other. NAUR-1 (0.84%) and GAR-2 (0.86%) showed moderate susceptibility and were at par with other, followed by IR-22 and GR-12 varieties were found moderately susceptible having 1.15 and 1.19 per cent damaged hills. Varieties IR-28, GR-11 and Masuri were found susceptible with 1.71, 1.76 and 1.82 per cent damaged hills, respectively and at par with other. The maximum per cent damaged hills were found in variety Gurjari (2.29), followed by Jaya (2.80). The interaction results between varieties and year were found non-significant showing consistent performance of different varieties.

Based on corrected per cent damage and scale (Table 35), the varieties having scale 1 viz., GR-101, GR-102, GR-103, GR-104 considered as resistant with 1 to 10% hill damage, while varieties having scale 3 viz., GNR-3, GNR-2, GR-7, GAR-1 and Narmada showed hill infestation ranged between 11 to 25% considered as moderately resistant. The varieties recorded hill damage between 26 to 50% having scale 5 were NAUR-1, GAR-2, GR-12 and IR-22 considered as moderately susceptible. However, varieties having scale 7 viz., IR-28, GR-11 and Masuri considered as susceptible with hill damage between 51 to 75% and the varieties having scale 9 viz., Jaya and Gurjari considered as highly susceptible with more than 76% hill damage.

Table 35: Varietal screening of rice against Brown plant hopper (Two years pooled)

Sr. No.	Varieties	% hill damage	Corrected % damage	Scale	Reaction
A.	Early Varieties				
1.	GR-7	4.47 (0.61)	21.82	3	MR
2.	GR-12	6.24 (1.19)	42.40	5	MS
3.	Gurjari	8.69 (2.29)	81.87	9	HS
4.	GNR-3	3.60 (0.41)	14.55	3	MR
5.	NAUR-1	5.25 (0.84)	30.11	5	MS
6.	GAR-1	4.25 (0.55)	19.80	3	MR
7.	GAR-2	5.32 (0.86)	30.89	5	MS
8.	IR-28	7.51 (1.71)	61.24	7	S
B.	Mid-late varieties				
9.	GR-11	7.60 (1.76)	62.79	7	S
10.	GNR-2	4.01 (0.50)	17.77	3	MR
11.	IR-22	6.14 (1.15)	41.14	5	MS
12.	Jaya (Sus. check)	9.62 (2.80)	--	9	HS
C.	Late varieties				
13.	Masuri	7.74 (1.82)	65.06	7	S
14.	GR-101	2.68 (0.22)	7.93	1	R
15.	GR-102	2.52 (0.20)	6.98	1	R
16.	GR-103	2.15 (0.14)	5.07	1	R
17.	GR-104	1.71 (0.09)	3.22	1	R
18.	Narmada	4.19 (0.58)	19.62	3	MR
S. E. (m) <u>+</u> (T)		0.17			
C. D. at 5% (T)		0.48			
S. E. (m) <u>+</u> (YxT)		0.27			
C. D. at 5% (YxT)		NS			
C. V. %		8.86			
* Values in outside the parentheses are arc sine transformed values and inside are original values.					

The similar type of trend was reported by Desai (2008) who showed that the minimum per cent damaged hills was found in variety GR-104 and highest in Jaya and Gurjari. Based on corrected per cent damage and scale, the varieties having scale 1 viz., IR-66, GR-101, GR-102, GR-103, GR-104 considered as resistant, varieties having scale 3 viz., GR-3, GR-6, GR-7, Narmada considered as moderately resistant, varieties having scale 5 viz., GR-10, Ratna, GR-12, IR-22 considered as moderately susceptible, varieties having scale 7 viz., IR-28, GR-11, Masuri considered as susceptible and varieties having scale 9 viz., Jaya and Gurjari considered as highly susceptible. However, in the findings of Cohen *et al.* (1997) showed slight to moderate levels of antibiosis, antixenosis in IR-64 and tolerance relative to the cultivars IR-22 Azucena, which contain no major genes for *N. lugens* resistance.

4.2.4 Earhead bug (*L. acuta*):

The data on per cent damaged grains per panicle due to earhead bug (Table 36-37 and Fig. 22) revealed that all varieties showed more or less per cent damaged grains. Bugs started infesting the panicles at milky stage and continue till hardening of grains. It was also observed that early maturing varieties showed higher per cent damaged grains.

i. I year (*Kharif* 2012):

The results of first year experiment (Table 36 and Fig. 22) revealed that none of the variety was found free from the attack of *L. acuta* and the difference in percentage of damaged grains per panicle in different varieties was found significant. However, among all varieties, significantly lower percentage of damaged grains were found in GR-104 (4.83%), which was found statistically at par with GAR-1 (5.93%), GNR-3 (5.96%), IR-22 (6.04%), GR-102 (6.17%) and GAR-2 (6.32%). Slightly higher percentage of damaged grains was found in GNR-2 (8.49%), which was at par with GR-12 (9.14%), GR-103 (9.93%), GR-7 (10.55%), GR-101(10.79%) and GR-7 (10.92%). The moderately higher damaged grains was recorded in Narmada with 11.18% and found at par with Gurjari (11.27%), NAUR-1 (11.97%) and Masuri (12.74%). Significantly

highest percentage of damaged grains per panicle was observed in IR-28 (17.09%) as well as in susceptible check Jaya (27.09%).

Table 36: Varietal screening of rice against earhead bug during *Kharif* 2012 and *kharif* 2013

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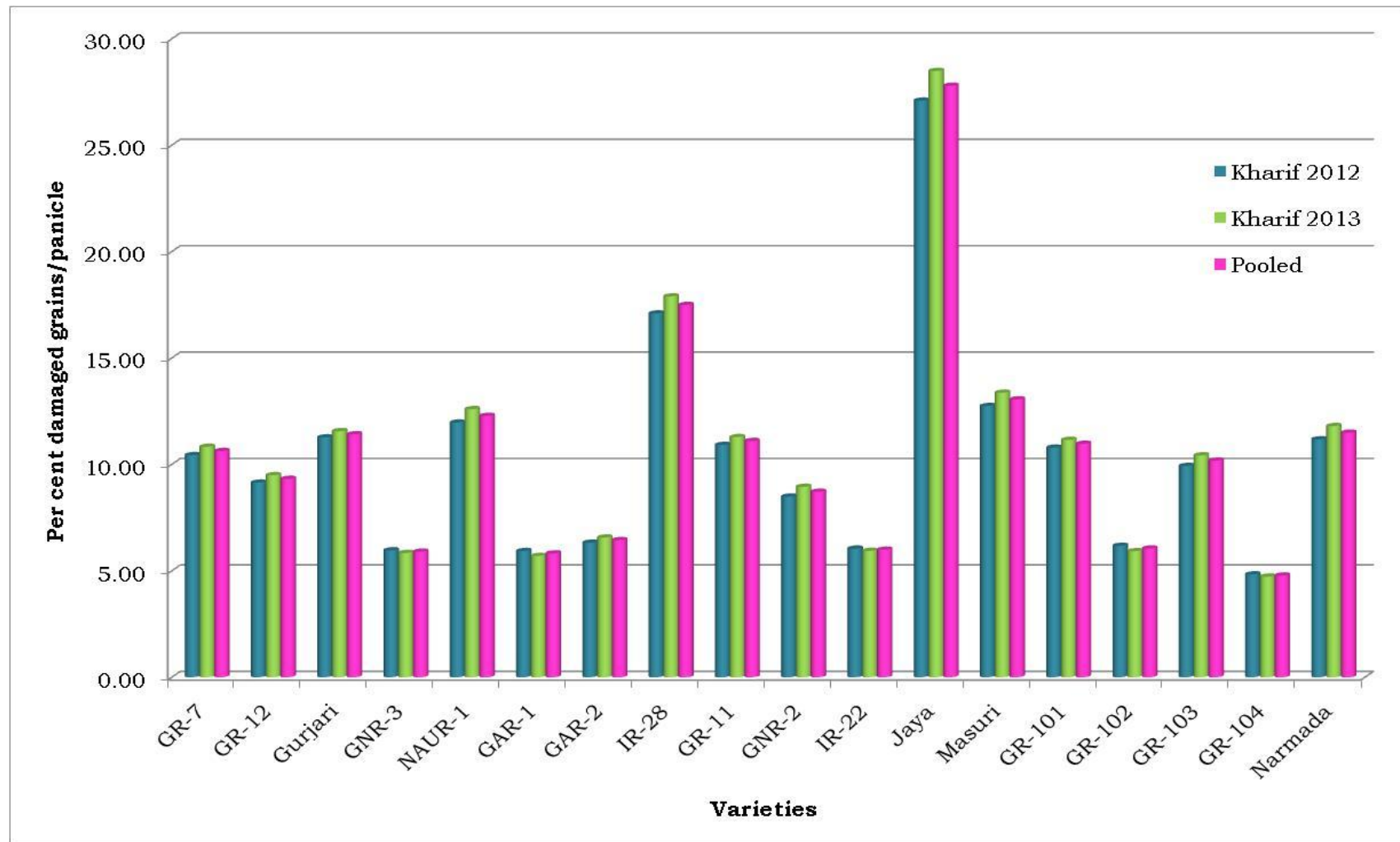


Fig. 22: Varietal screening of rice against earhead bug

ii. II year (Kharif 2013):

The data of second year on per cent damaged grains presented in Table 36 and Fig. 22 revealed that difference in per cent damaged grains in different varieties was found significant. However, among all varieties significantly lowest percentage of damaged grains was found in GR-104 (4.73%), which was at par with GAR-1 (5.70%), GNR-3 (5.84%), GR-102 (5.92%), IR-22 (5.94%) and GAR-2 (6.57%). The other varieties which showed comparatively lower percentage of damaged grains were GNR-2 (8.95%), GR-12 (9.49%), GR-103 (10.42%), GR-7 (10.83%), GR-101 (11.15%), GR-11 (11.28%) and Gurjari (11.56%) and were found at par with each other. The variety Narmada, NAUR-1 and Masuri recorded 11.80, 12.60 and 13.37 per cent damaged grain, which was lower than the susceptible check variety Jaya. Significantly highest percentage of damaged grains was found in IR-28 (17.89%) and Jaya (28.49%).

iii. Pooled:

The pooled results of varietal screening against earhead bug (Table 37 and Fig. 22) indicated that none of the variety was free from the attack of *L. acuta* and the difference in percentage of damaged grains per panicle in different varieties was found significant. However, among all varieties, significantly lower percentage of damaged grains was recorded in GR-104 (4.78%), which was statistically at par with GAR-1 (5.82%), GNR-3 (5.90%) and IR-22 (5.99%). Similarly lower damaged grains were also seen in GR-102 and GAR-2, which recorded 6.05 and 6.44 per cent damage and found at par with each other. Slightly higher percentage of damaged grains was found in GNR-2 (8.72%), which was at par with GR-12 (9.32%) and GR-103 (10.18%). The moderately higher damaged grains per cent was recorded in GR-7 with 10.63% damage and showed at par findings with GR-101 (10.97%), GR-11 (11.10%), Gurjari (11.42%), Narmada (11.49%) and NAUR-1 (12.28%). Masuri recorded significantly higher susceptibility with 13.06% panicle damage, but significantly highest percentage of damaged grains per panicle was observed in IR-28 (17.49%) as well as in susceptible check Jaya (27.79%). The interaction effect between varieties and year was non-

significant showing consistent performance of different varieties during the period of both years.

Based on per cent damaged grains per panicle due to earhead bug is presented in Table 37, the varieties *viz.*, GR-104, GAR-1, GNR-3, IR-22, GR-102 and GAR-2 found moderately resistant in the scale 3 (4-7% grain damage). Whereas, the other varieties like GNR-2, GR-12, GR-103, GR-7, GR-101, GR-11, Gurjari, Narmada, NAUR-1 and Masuri were categorized into moderately susceptible group of scale 5 (8-15% grain damage). The variety IR-28 fit into susceptible group of scale 7 (16-25% grain damage), while Jaya was categorized into highly susceptible class of scale 9 (26-100% grain damage).

These results are concerned with Diwakar (1975), Grist (1981) and Saroja and Raju (1985) who reported that the earhead bugs remained in the field till the grain hardening take place and the successive generations migrated from early maturing varieties to late maturing varieties and cause serious damage. While, similar type of screening trend was found in the results of Ghule (2006) who showed that the varieties *viz.*, IR-28, GR-10, GR-6, GR-7, GR-3, GR-9, Kada, IR-66, TN1, Gurjari, GR-12 and GR-102 were moderately resistant and the remaining varieties *viz.*, GR-4, GR-5, Ratna, GR-11, Jaya, GR-103, GR-101, Masuri and GR-104 were slightly resistant to earhead bugs. He also found that the incidence of rice earhead bug was greater in mid-late and late maturing varieties as compared to early maturing varieties.

In another findings of Mandape (2013) revealed that the variety Pawana was resistant having 1 scale, varieties *viz.*, IR-22, GR-9, GR-102 and GR-104 showed moderately resistant reaction having 3 scale, while varieties *viz.*, NAUR-1, GR-4, GR-6, GR-7, GR-10, GR-11, GR-12, GR-101, GR-103, Gurjari, Narmada and PR 116 were slightly resistant having scale 5. The varieties *viz.*, IR-28 and IR-50 were susceptible with scale 7, while remaining varieties *viz.*, IR-66, Dandi, Jaya and PRH-10 showed highly susceptible reaction with scale 9. Thus, this result confirms the findings of present investigation.

Table 37: Varietal screening of rice against earhead bug (Two years pooled)

Sr. No.	Varieties	% damaged grain/ panicle	Scale	Reaction
A.	Early Varieties			
1.	GR-7	18.95 (10.63)	5	MS
2.	GR-12	17.74 (9.32)	5	MS
3.	Gurjari	19.69 (11.42)	5	MS
4.	GNR-3	14.04 (5.90)	3	MR
5.	NAUR-1	20.46 (12.28)	5	MS
6.	GAR-1	13.94 (5.82)	3	MR
7.	GAR-2	14.69 (6.44)	3	MR
8.	IR-28	24.70 (17.49)	7	S
B.	Mid-late varieties			
9.	GR-11	19.42 (11.10)	5	MS
10.	GNR-2	17.16 (8.72)	5	MS
11.	IR-22	14.13 (5.99)	3	MR
12.	Jaya (Sus. check)	31.81 (27.79)	9	HS
C.	Late varieties			
13.	Masuri	21.15 (13.06)	5	MS
14.	GR-101	19.31 (10.97)	5	MS
15.	GR-102	14.19 (6.05)	3	MR
16.	GR-103	18.55 (10.18)	5	MS
17.	GR-104	12.59 (4.78)	3	MR
18.	Narmada	19.75 (11.49)	5	MS
S. E. (m) ₊ (T)		0.56		
C. D. at 5% (T)		1.58		
S. E. (m) _± (YxT)		0.88		
C. D. at 5% (YxT)		NS		
C. V. %		8.23		
* Values in outside the parentheses are arc sine transformed values and inside are original values.				

4.2.5 Leaf folder (*C. medinalis*):

The data on per cent damaged leaves due to leaf folder is presented in Table 38-39 and graphically depicted in Fig. 23. The results showed that all varieties showed more or less per cent damaged leaves.

i. I year (*Kharif 2012*):

The first year findings on per cent damaged leaves (Table 38 and Fig. 23) revealed significant differences in eighteen varieties. However among all varieties evaluated, the variety GR-102 exhibited least 0.31% damage of the leaf folder and was statistically at par with GR-103 (0.32%), GNR-3 (0.32%), Gurjari (0.37%) and IR-22 (0.45%), followed by the variety GNR-2 registered 0.47% damage and was at par with NAUR-1 (0.48%) and IR-28 (0.54%). The variety GAR-1, GR-7, Narmada and GAR-2 registered 0.66, 0.69, 0.79 to 0.83 per cent leaf damage due to leaf folder and were at par with each other. Among the tested varieties, GR-11, GR-101 and GR-12 showed significantly higher leaf damage of 0.92, 1.59 and 2.38 per cent due to leaf folder, respectively, followed by Jaya (2.82%) and GR-104 (3.08%) and were at par with each other. While, the highest leaf damage of 3.55% was recorded in Masuri.

ii. II year (*Kharif 2013*):

The results of second year on evaluation of screening in different varieties (Table 38 and Fig. 23) indicated significant differences in per cent damaged leaves. Among all varieties, GR-103 and GR-102 exhibited least 0.18 and 0.24% damage of the leaf folder, respectively and statistically at par with each other. The varieties *viz.*, IR-22, GNR-3, GNR-2, Gurjari, NAUR-1 and GAR-1 registered 0.48, 0.49, 0.50, 0.52, 0.55 and 0.56 per cent damaged leaves, respectively and were statistically at par with each other, which was followed by IR-28 and GR-7 showed 0.67% damaged and found at par with each other as well as with previous last five varieties. The variety Narmada, GAR-2 and GR-11 recorded 0.90, 0.92 and 1.04 per cent leaf damage due to leaf folder, respectively and were at par with each other. Among the tested other

varieties, GR-101, GR-12, Jaya and GR-104 revealed significantly higher leaf damage of 1.58, 2.82, 2.91 and 3.11 per cent due to leaf folder, respectively, later two were at par with each other. While, the highest leaf damage of 3.65 per cent was found in Masuri.

Table 38: Varietal screening of rice against leaf folder during *Kharif* 2012 and 2013

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* Values in outside the parentheses are arc sine transformed values and inside are original values.

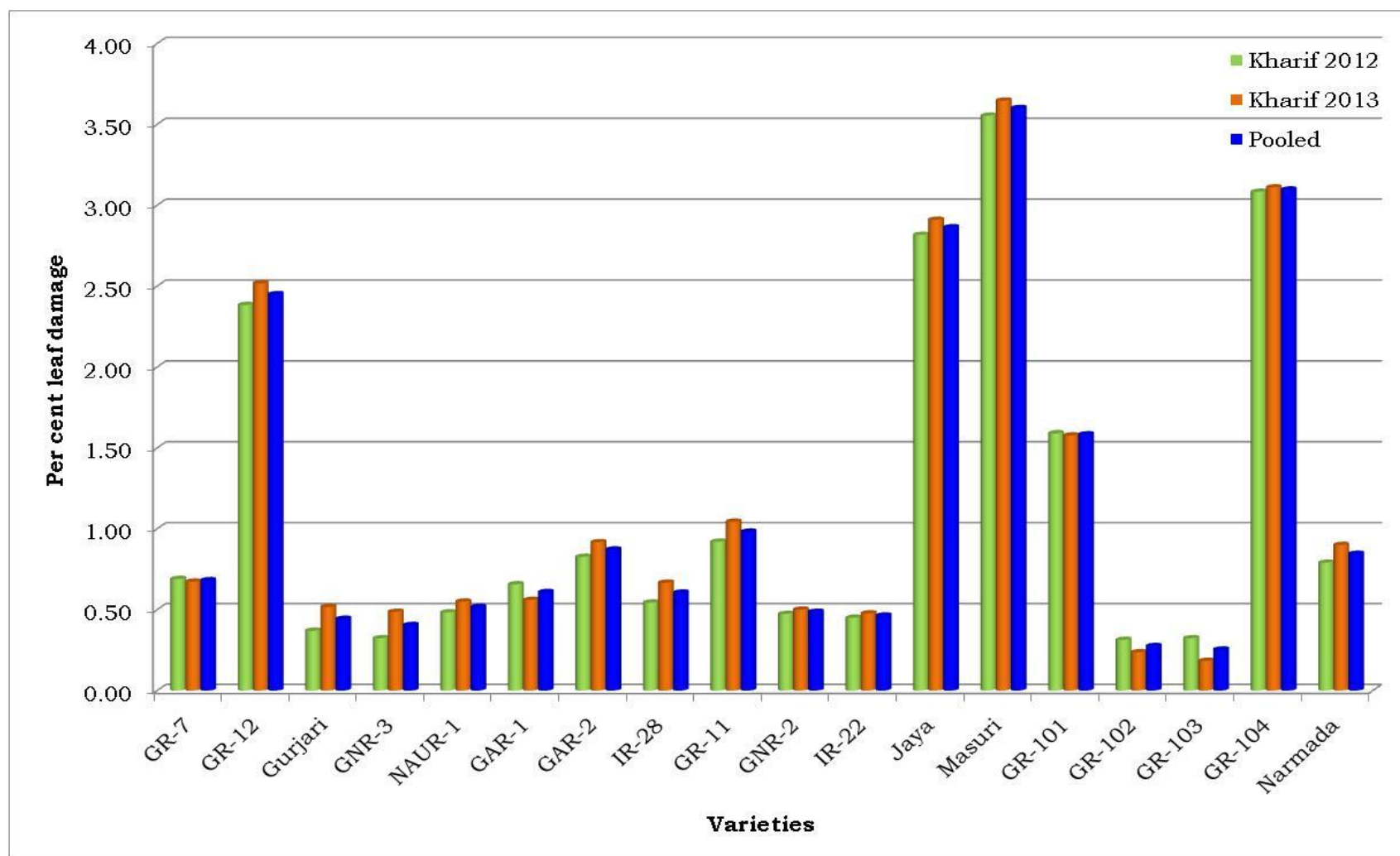


Fig. 23: Varietal screening of rice against leaf folder

iii. Pooled:

The pooled data on per cent damaged leaves (Table 39 and Fig. 23) indicated significant differences in eighteen varieties. Among all varieties of paddy evaluated, the varieties GR-103 and GR-102 exhibited least 0.25 and 0.28 % damage of the leaf folder, respectively and statistically at par with each other. The varieties *viz.*, GNR-3 (0.41%), Gurjari (0.44%), IR-22 (0.46%) and GNR-2 (0.49%) were found significantly more resistant than remaining varieties and at par with each other. This resistant trend was followed by the varieties like NAUR-1, IR-28 and GAR-1, which registered 0.52, 0.61 and 0.61 per cent damage and was at par with each other. The variety GR-7 (0.68%) showed significantly moderate resistant leaf damage due leaf folder, followed by Narmada, GAR-2 and GR-11 registered 0.85, 0.87. and 0.98 per cent leaf damage due to leaf folder and were at par with each other. Among the other tested varieties, GR-101 and GR-12 showed significantly higher leaf damage of 1.58 and 2.45% due to leaf folder, respectively, followed by Jaya (2.86%) and GR-104 (3.10%) and both were at par with each other. The highest leaf damage of 3.60% was observed in Masuri. The interaction effect between varieties and year was non-significant, which revealed consistent performance of different varieties during the period of both years.

Based on corrected per cent leaf damage and scale (Table 39), the varieties having scale 1 are GR-102, GR-103 considered as resistant with 1 to 10% leaf damage, while eight varieties having scale 3 and considered as moderately resistant are GNR-3, Gurjari, IR-22, GNR-2, NAUR-1, IR-28, GAR-1 and GR-7 showed leaf infestation ranged between 11 to 20%. The varieties recorded leaf damage between 21 to 35% having scale 5 are Narmada, GAR-2 and GR-11 were considered as moderately susceptible. The variety GR-101 found susceptible in scale 7 with leaf damage between 36-50%. However, varieties considered as highly susceptible having scale 9 are GR-12, Jaya, GR-104 and Masuri with leaf damage between 51 to 100%.

Table 39: Varietal screening of rice against leaf folder (Two years pooled)

Sr. No.	Varieties	% leaf damage	Corrected % damage	Scale	Reaction
A.	Early Varieties				
1.	GR-7	4.72 (0.68)	18.94	3	MR
2.	GR-12	8.99 (2.45)	68.06	9	HS
3.	Gurjari	3.78 (0.44)	12.31	3	MR
4.	GNR-3	3.62 (0.41)	11.25	3	MR
5.	NAUR-1	4.10 (0.52)	14.35	3	MR
6.	GAR-1	4.47 (0.61)	16.90	3	MR
7.	GAR-2	5.35 (0.87)	24.21	5	MS
8.	IR-28	4.43 (0.61)	16.81	3	MR
B.	Mid-late varieties				
9.	GR-11	5.67 (0.98)	27.27	5	MS
10.	GNR-2	4.00 (0.49)	13.52	3	MR
11.	IR-22	3.89 (0.46)	12.87	3	MR
12.	Jaya	9.74 (2.86)	79.54	9	HS
C.	Late varieties				
13.	Masuri (Sus. check)	10.93 (3.60)	100	9	HS
14.	GR-101	7.21 (1.58)	43.98	7	S
15.	GR-102	3.00 (0.28)	7.64	1	R
16.	GR-103	2.83 (0.25)	7.04	1	R
17.	GR-104	10.13 (3.10)	86.02	9	HS
18.	Narmada	5.27 (0.85)	23.47	5	MS
S. E. (m) _± (T)		0.17			
C. D. at 5% (T)		0.48			
S. E. (m) _± (YxT)		0.24			
C. D. at 5% (YxT)		NS			
C. V. %		7.21			
* Values in outside the parentheses are arc sine transformed values and inside are original values					

In earlier findings, Korat *et al.* (2003^b) showed significantly low incidence of leaf folder in IET-12150 and IET-12537 cultivar than susceptible check Jaya and GR-11 cultivar, while Nigam *et al.* (2008) from Faizabad reported rice germplasms *viz.*, IET 13310, NDR 6023, IET 10649-1, Masuri, NDR 6232 and NDR 6175 were resistant to leaf folder damage. These findings support the present experimental results.

However, Patel (2006) revealed that the minimum per cent damaged leaves was found in variety GR-103 coincided with scale 1, followed by the variety GR-102, GR-11, IR-28, kada, GR -7, Ratna, GR -3, GR -101, GR -12, GR -1, GR -5, TN-1, Jaya, GR-9, IR-66, GR-10, GR-6, Gurjari, GR-104 and Masuri. Likewise, in the results of Sankpal (2011), the genotype NWGR-7075 exhibited significantly least damage of the leaf folder than IET-21568, NWGR-7028, IET-21582, NWGR-4014, NWGR-4011 and NWGR-6072. Variety GR-11 showed significantly highest leaf damage due to *C. medinalis*, followed by GR-4 and GR-12. These results confirm and support the present investigation data.

Also, similar type of trend was found in the experiment of Gole (2012) who reported that the genotype NWGR-4031 and variety Gurjari exhibited significantly least damage of the leaf folder. Among the tested genotypes/varieties, GR-11 showed significantly highest (9.55%) leaf damage due to leaf folder.

4.2.6 Blue Beetle (*L. pygmaea*):

The data on per cent damaged leaves due to blue beetle is presented in Table 40 and 41 and graphically depicted in Fig. 24. The findings showed that all varieties showed more or less per cent damaged leaves and none of the varieties was found to be free from infestation. The infestation was observed at early period of crop.

i. I year (*Kharif* 2012):

The first year data (Table 40 and Fig. 24) on per cent leaf damage due to blue beetle recorded significant results and revealed that the infestation of the pest in different varieties was varied from 0.12 to 2.35

per cent. From the varieties screened, significantly lowest infestation was registered in variety GR-102 (0.12%) and was found comparable with GAR-1 (0.14%), GR-103 (0.14%), IR-22 (0.14%), GAR-2 (0.15%), GNR-2 (0.17%) and GR-104 (0.18%). Similarly, varieties GR-7 and GNR-3 also registered significantly lower infestation of 0.31 and 0.32% than susceptible check GR-11 and also found at par with each other, followed by 0.43% leaf damage in GR-12 and IR-22. The other variety *viz.*, GR-101 (0.65%) was less effective variety, but it was at par with Narmada (0.65%) and NAUR-1 (0.70%). Varieties like Masuri, Gurjari and Jaya were also less effective amongst above other varieties and were at par with each other with 1.23, 1.30 and 1.32 per cent leaf damage, respectively. The paddy variety GR-11 registered highest (2.35%) infestation due to blue beetle.

ii. II year (*Kharif* 2013):

The results of second year on per cent leaf damage due to blue beetle showed significant findings (Table 40 and Fig. 24). From the varieties screened, significantly lowest infestation was exhibited in variety GAR-1 (0.10%), but recorded at par results with IR-22 (0.13%), GR-102 (0.13%), GAR-2 (0.14%), GNR-2 (0.14%) and GR-103 (0.17%). Similarly, varieties GR-104 and GNR-3 also registered significantly lower infestation of 0.20 and 0.30%, respectively and found at par with each other. This trend of ascending order leaf damage was followed by the varieties like GR-7, GR-12 and IR-28 registering 0.35, 0.39 and 0.40 per cent leaf damage, respectively. Later on, GR-101 (0.71%) was less effective variety and it was also at par with Narmada (0.73%) and NAUR-1 (0.76%). The varieties *viz.*, Masuri and Gurjari were also less effective amongst above other varieties and were at par with each other with 1.26, and 1.37 per cent leaf damage, respectively. The paddy varieties Jaya (1.45%) and GR-11 (2.33%) registered highest infestation due to blue beetle.

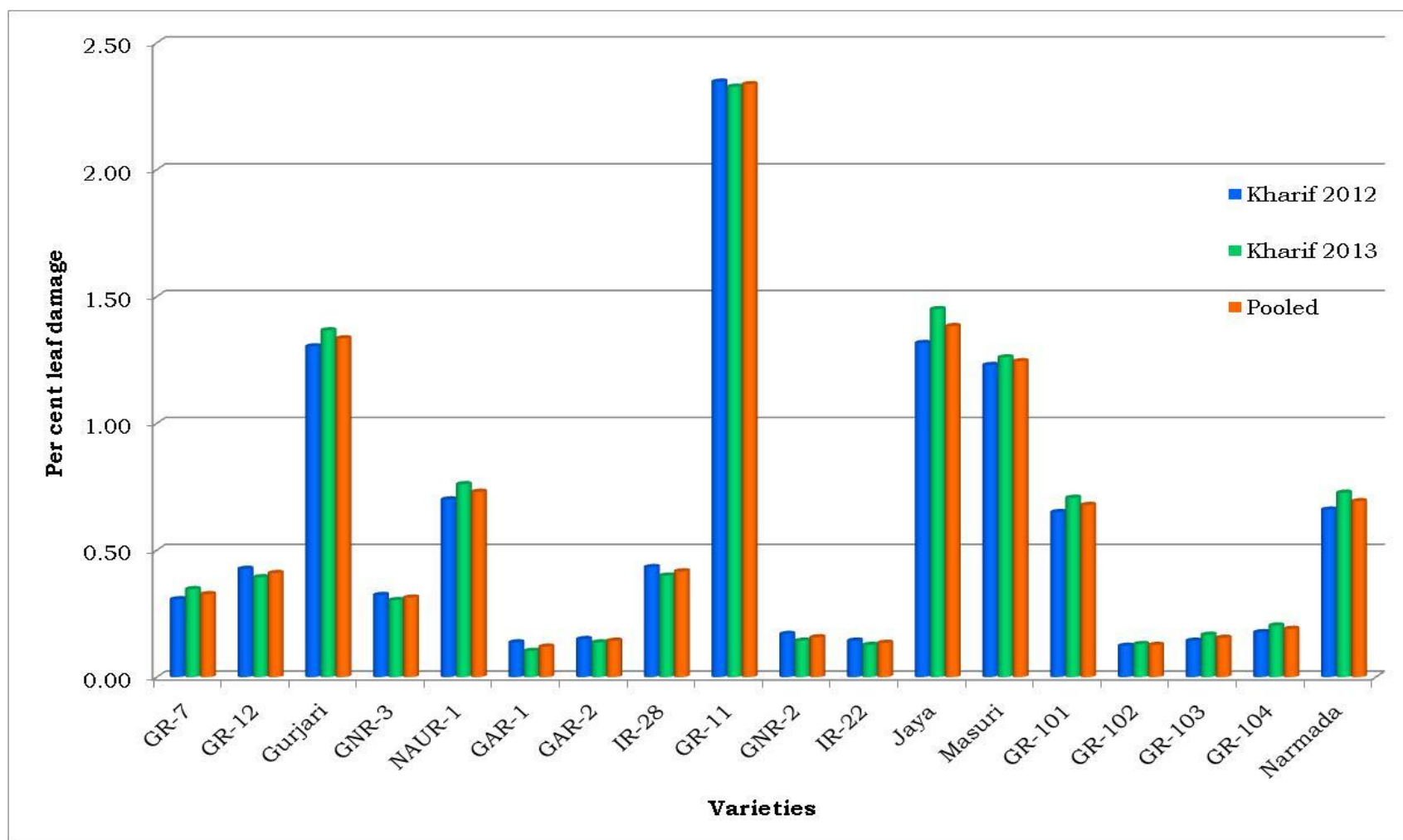


Fig. 24: Varietal screening of rice against blue beetle

iii. Pooled:

The pooled data (Table 41 and Fig. 24) on per cent leaf damage due to blue beetle recorded significant results and revealed that the infestation of the pest in different varieties was varied from 0.12 to 2.34%. From the 18 varieties screened, significantly lowest infestation was registered in variety GAR-1 (0.12%) and was showed at par results with GR-102 (0.13%), IR-22 (0.14%) and GAR-2 (0.14%). Similarly, GR-103 and GNR-2 were registered 0.16 per cent leaf damage and found less susceptible to blue beetle, followed by GR-104 (0.19%). The varieties GNR-3 and GR-7 also registered significantly lower infestation of 0.31 and 0.33% than susceptible check GR-11 and also found at par with each other. These were followed by GR-12, IR-22, GR-101, Narmada and NAUR-1 exhibited 0.41, 0.42, 0.68, 0.69 and 0.73 per leaf damage, respectively and were less effective varieties, where former two and later three were at par with each other. Masuri (0.125%) was less effective amongst above other varieties, followed by Gurjari and Jaya with 1.34 and 1.38 per cent leaf damage, respectively. The paddy variety GR-11 registered highest (2.34%) infestation due to blue beetle.

The interaction effect between varieties and year was non-significant, which revealed consistent performance of different varieties during the period of both years.

Based on corrected per cent leaf damage and scale (Table 41), the seven varieties having scale 1 are GAR-1, GR-102, IR-22, GAR-2, GR-103, GNR-2 and GR-104 considered as resistant with 1 to 10% leaf damage, while four varieties grouped under scale 3 *viz.*, GNR-3, GR-7, IR-12 and IR-28 showed leaf infestation ranged between 11 to 25% considered as moderately resistant. The varieties recorded leaf damage between 26 to 50% having scale 5 are GR-101, Narmada and NAUR-1 considered as moderately susceptible. However, varieties having scale 7 *viz.*, Masuri, Gurjari and Jaya considered as susceptible with leaf damage between 51 to 75%, while the variety having scale 9 is Jaya considered as highly susceptible with 100% leaf damage.

Table 41: Varietal screening of rice against blue beetle (Two years pooled)

Sr. No.	Varieties	% leaf damage	Corrected % damage	Scale	Reaction
A.	Early Varieties				
1.	GR-7	3.26 (0.33)	13.98	3	MR
2.	GR-12	3.66 (0.41)	17.55	3	MR
3.	Gurjari	6.63 (1.34)	57.13	7	S
4.	GNR-3	3.20 (0.31)	13.41	3	MR
5.	NAUR-1	4.89 (0.73)	31.24	5	MS
6.	GAR-1	1.97 (0.12)	5.14	1	R
7.	GAR-2	2.16 (0.14)	6.13	1	R
8.	IR-28	3.70 (0.42)	17.83	3	MR
B.	Mid-late varieties				
9.	GR-11 (Sus. check)	8.77 (2.34)	100	9	HS
10.	GNR-2	2.26 (0.16)	6.70	1	R
11.	IR-22	2.09 (0.14)	5.78	1	R
12.	Jaya	6.74 (1.38)	59.20	7	S
C.	Late varieties				
13.	Masuri	6.40 (1.25)	53.28	7	S
14.	GR-101	4.71 (0.68)	29.03	5	MS
15.	GR-102	2.03 (0.13)	5.42	1	R
16.	GR-103	2.24 (0.16)	6.63	1	R
17.	GR-104	2.49 (0.19)	8.13	1	R
18.	Narmada	4.77 (0.69)	29.67	5	MS
S. E. (m) ₊ (T)		0.14			
C. D. at 5% (T)		0.40			
S. E. (m) ₊ (YxT)		0.20			
C. D. at 5% (YxT)		NS			
C. V. %		8.87			
* Values in outside the parentheses are arc sine transformed values and inside are original values.					

The present experimental results are matching with the findings of Patel (2008) who showed that the varieties having scale 1 were IR-22, GR-102, GR-103 and GR-104 considered as resistant, varieties having scale 3 are IR-28, GR-6, GR-7, Ratna and GR-12 considered as moderately resistant, varieties having scale 5 *viz.*, GR-10, Narmada and GR-101 as moderately susceptible, varieties having scale 7 *viz.*, Gurjari, Jaya and Masuri considered as susceptible and varieties having scale 9 *viz.*, GR-3, GR-11 and GR-66 considered as highly susceptible.

4.2.7 Sheath mite (*S. pinkii*):

The data on mean number of mites per leaf sheath is presented in Table 42 and Fig. 25. The findings showed that all varieties showed more or less number of mites and none of varieties free from mite population.

i. I year (*Kharif* 2012):

The first year results on population of mites (Table 42 and Fig. 25) revealed significant differences in eighteen varieties. However among all varieties evaluated, variety Masuri significantly recorded minimum mite incidence (1.55/leaf sheath), followed by IR-28 (2.72/leaf sheath). Similarly, varieties GR-101 (5.42/leaf sheath) and GNR-3 (5.57/leaf sheath) also recorded less mite population. The varieties *viz.*, GR-102, GR-11, GR-104, GAR-1, GAR-2, IR-22, GR-7 and GR-12 recorded 7.45, 7.48, 7.49, 7.64, 7.64, 8.39, 8.40 and 8.64 per leaf sheath, respectively and was found at par with each other. The variety Narmada (9.37/leaf sheath), GNR-2 (9.47/leaf sheath) and GR-103 (9.85/leaf sheath) registered moderate mite incidence and showed at par findings with each other, while higher mite incidence was found in NAUR-1 (14.60/leaf sheath) and Gurjari (16.43/leaf sheath). The highest mite population was recorded in Jaya (22.67/leaf sheath).

ii. II year (*Kharif* 2013):

The mite population data of second year (Table 42 and Fig. 25) indicated significant differences and among all varieties, variety IR-28 (2.50/leaf sheath) and Masuri (2.57/leaf sheath) showed significantly

minimum mite incidence and found at par with each other. Varieties GR-101, GR-104, GNR-3 GR-7, GR-102 and GAR-1 also recorded less mite population of 6.08, 6.17, 6.37, 6.73, 7.09 and 7.20 per leaf sheath, respectively and were at par with each other. The varieties *viz.*, GAR-2 (8.15/leaf sheath), GR-11 (8.21/leaf sheath), GR-103 (8.95/leaf sheath) and Narmada (9.67/leaf sheath) also showed less mite incidence and found comparable with each other. Variety IR-22 and GR-12 recorded moderate population of 9.71 and 9.80/leaf sheath and was at par with each other. Variety GNR-2 (10.43/leaf sheath) showed significantly moderate incidence, followed by NAUR-1 (16.48/leaf sheath) and Gurjari (17.27/leaf sheath) and both were at par with each other. The highest mite population was recorded in Jaya (20.77/leaf sheath).

iii. Pooled:

The pooled data on population of mites (Table 42 and Fig. 25) revealed significant differences in eighteen varieties. Variety Masuri recorded minimum mite incidence (2.06/leaf sheath), followed by IR-28 (2.61/leaf sheath) and both were found at par with other. Similarly, varieties like GR-101, GNR-3 and GR-104 also recorded less mite population of 5.75, 5.97 and 6.83 per leaf sheath and were comparable with each other. The varieties *viz.*, GR-102 (7.27/leaf sheath), GAR-1 (7.42/leaf sheath), GR-7 (7.57/leaf sheath), GR-11 (7.85/leaf sheath) and GAR-2 (8.01/leaf sheath) also registered less mite incidence and were found at par with each other. The variety which recorded moderate mite population were IR-22 (9.05/leaf sheath), GR-12 (9.22/leaf sheath), GR-103 (9.40/leaf sheath), Narmada (9.52/leaf sheath) and GNR-2 (9.95/leaf sheath) and showed at par findings with each other, while moderate mite incidence was found in NAUR-1 (15.54/leaf sheath) and higher incidence in Gurjari (16.85/leaf sheath), but found at par with each other. The highest mite population was recorded in Jaya (21.72/leaf sheath). The interaction effect between varieties and year was non-significant, which revealed consistent performance of different varieties during the period of both years.

Table 42: Varietal screening of rice against sheath mite during *Kharif* 2012, 2013 and pooled

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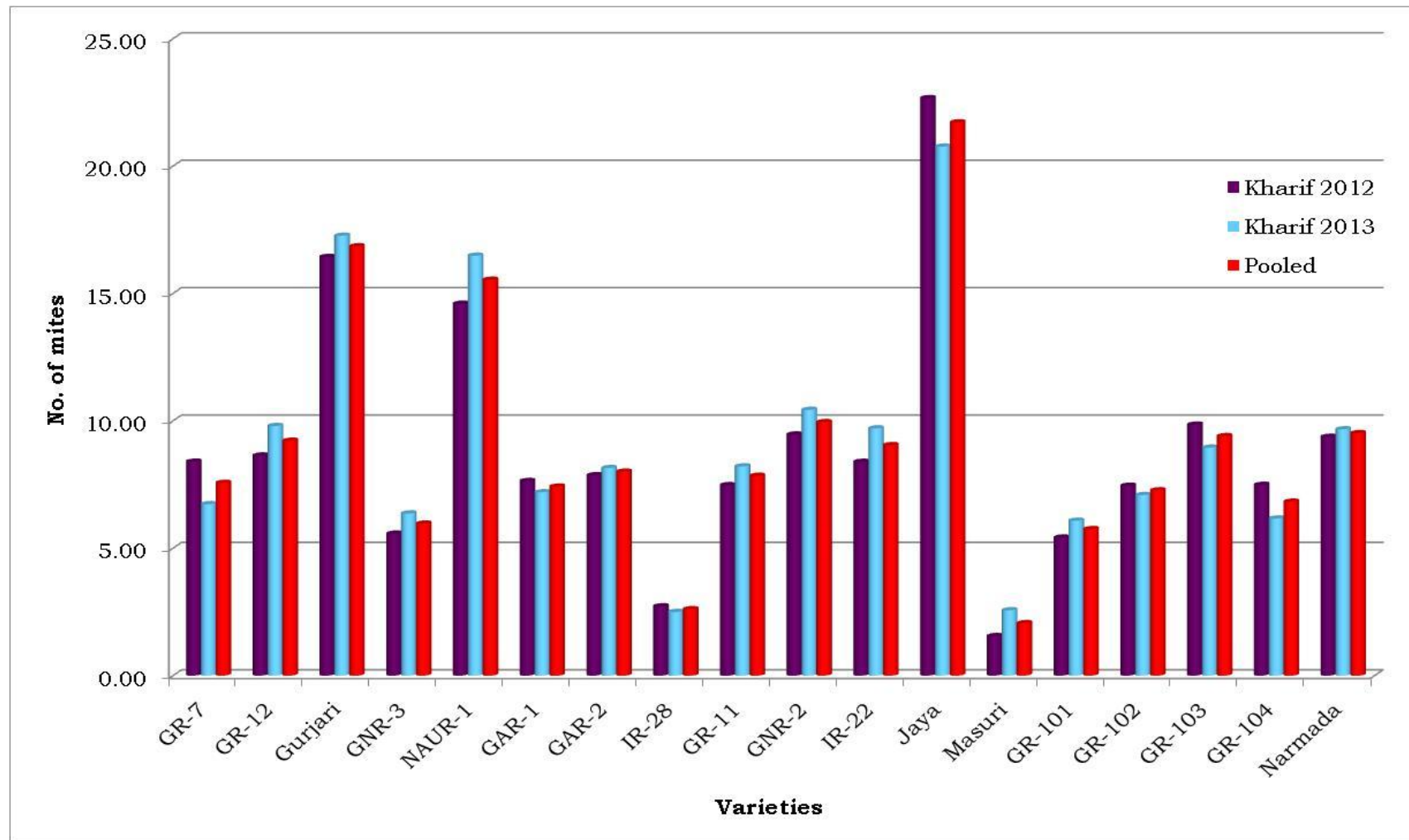


Fig. 25: Varietal screening of rice against sheath mite

Based on mite population (Table 42) the varieties Masuri and IR-28 are found promising varieties, while eight varieties which considered as less susceptible are GR-101, GNR-3, GR-104, GR-102, GAR-1, GR-7 and GR-11 showed less infestation. The six varieties recorded moderate population and grouped into moderately susceptible are IR-22, GR-12, GR-103, Narmada, GNR-2 and NAUR-1. However, varieties considered as highly susceptible are Gurjari and Jaya.

Earlier, Bandhanja (2005) showed that the early varieties like IR-50, GR-3 and IR-28 recorded minimum mite incidence, while higher incidence was found in GR-7 and IR-21. Whereas in case of mid late varieties, Masuri reported minimum mite incidence, followed by GR-10 and GR-101. However, other varieties like GR-11, Narmada and GR-102 showed moderate population and Gurjari, GR-103 and Jaya found more susceptible. This findings match with the present investigation results.

Likewise, present results are also supported by Rao and Prakash (1985) who reported rice varieties like Ratna, Karuna, Savitri, Jaya, Udaya, CR-1014, Vijaya, Pusha 2-21, Kalinga-1, Supriya and Jaganath were highly susceptible to the incidence of mite, *Tyrophagous palmerum*. The data on population of *S. spinki* showed that the highest incidence was recorded in variety GR-5, followed by other varieties viz., Jaya, Gurjari, GR-11 and GR-4, which also showed higher level of mite infestation (Anonymous, 2014), which support the present findings.

4.3 Efficacy of insecticides against rice yellow stem borer:

The data on per cent infestation due to yellow stem borer at 3, 7 and 10 days after first and second spray are presented in Table 43 to 45 and depicted Fig. 26 to 31.

4.3.1 First Year (Kharif 2012):

a. First spray:

i. Pre-treatment:

The performance of different insecticides against yellow stem borer management at first spray before spraying (Table 43 and Fig. 26) showed

non-significant results. This showed the infestation was equally distributed in the treatment plots.

ii. At 3 DAS:

The per cent dead hearts due to yellow stem borer at 3 days after on first spray (Table 43 and Fig. 26) revealed significant results and fipronil 0.3G (T₂) with 3.02% dead hearts found superior among all insecticides, but was at same level with spinosad 45 SC (T₃) (3.43%). The next best treatment was profenophos 50 EC (T₁) which recorded 4.02% dead hearts and found comparable with cartap hydrochloride (T₄) (4.17%). The highest dead heart damage of 5.12% due to stem borer was observed in control plot (T₅).

iii. At 7 DAS:

The similar type of trend on performance of insecticides against yellow stem borer was recorded at 7 days after on first spray (Table 43 and Fig. 26) and showed significant results. The lowest number of dead heart was found fipronil 0.3 G (T₂) (3.19%), followed by spinosad 45 SC (T₃) (3.47%) and they were at par with each other. The next best treatments were profenophos 50 EC (T₁) (4.20%) and cartap hydrochloride (T₄) (4.31%) that were at par with each other. The highest dead heart damage of 6.09% was observed in control plot (T₅).

iv. At 10 DAS:

At 10 DAS, the similar type of trend insecticides efficacy against yellow stem borer was recorded with significant results (Table 43 and Fig. 26). The minimum damage was recorded fipronil 0.3 G (T₂) (3.58%), followed by spinosad 45 SC (T₃) (3.72%) and they were comparable with each other. The other treatments *viz.*, profenophos 50 EC (T₁) (4.73%) and cartap hydrochloride (T₄) (4.56%) also showed significantly lower damage over control (6.12%), but previous two were at par with each other. The infestation in control showed increasing trend in successive days of crop season.

Table 43: Effectiveness of insecticides against rice yellow stem borer during *Kharif* 2012

Sr. No.	Treatments	Before spray	% DH after first spray			% DH after second spray		
			3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
1.	Profenophos 50 EC	14.38 (6.20)	11.54 (4.02)	11.82 (4.20)	12.14 (4.43)	10.26 (3.18)	10.57 (3.38)	10.86 (3.57)
2.	Fipronil 0.3 G	14.02 (5.96)	9.97 (3.02)	10.26 (3.19)	10.88 (3.58)	8.90 (2.42)	9.08 (2.51)	9.24 (2.61)
3.	Spinosad 45 SC	13.99 (5.90)	10.66 (3.43)	10.68 (3.47)	11.10 (3.72)	9.39 (2.67)	9.67 (2.83)	9.79 (2.90)
4.	Cartap hydrochloride 4 G	14.30 (6.11)	11.78 (4.17)	11.94 (4.31)	12.31 (4.56)	10.52 (3.35)	10.76 (3.51)	10.92 (3.60)
5.	Control (water)	13.05 (5.12)	13.05 (5.12)	14.28 (6.09)	14.25 (6.12)	14.57 (6.34)	14.73 (6.47)	14.83 (6.58)
S. E. (m) _±		0.45	0.29	0.36	0.35	0.28	0.29	0.32
C. D. at 5%		NS	0.87	1.08	1.03	0.82	0.86	0.94
C. V.		7.89	6.33	7.57	7.07	6.32	6.48	7.01
* Values in outside the parentheses are arc sine transformed values and inside are original values.								

b. Second spray:**i. At 3 DAS:**

The effect of insecticides after second spray on per cent dead heart due to yellow stem borer at 3 DAS (Table 43 and Fig. 27) indicated significant results and fipronil 0.3 G (T₂) recorded low of 2.42% dead hearts, which was superior among all insecticides, but was at par with spinosad 45 SC (T₃) (2.67%). The next best treatment was profenophos 50 EC (T₁) that recorded 3.18% dead hearts and found at par with cartap hydrochloride (T₄) (3.35%). The highest dead heart damage of 6.34% was observed in control plot (T₅).

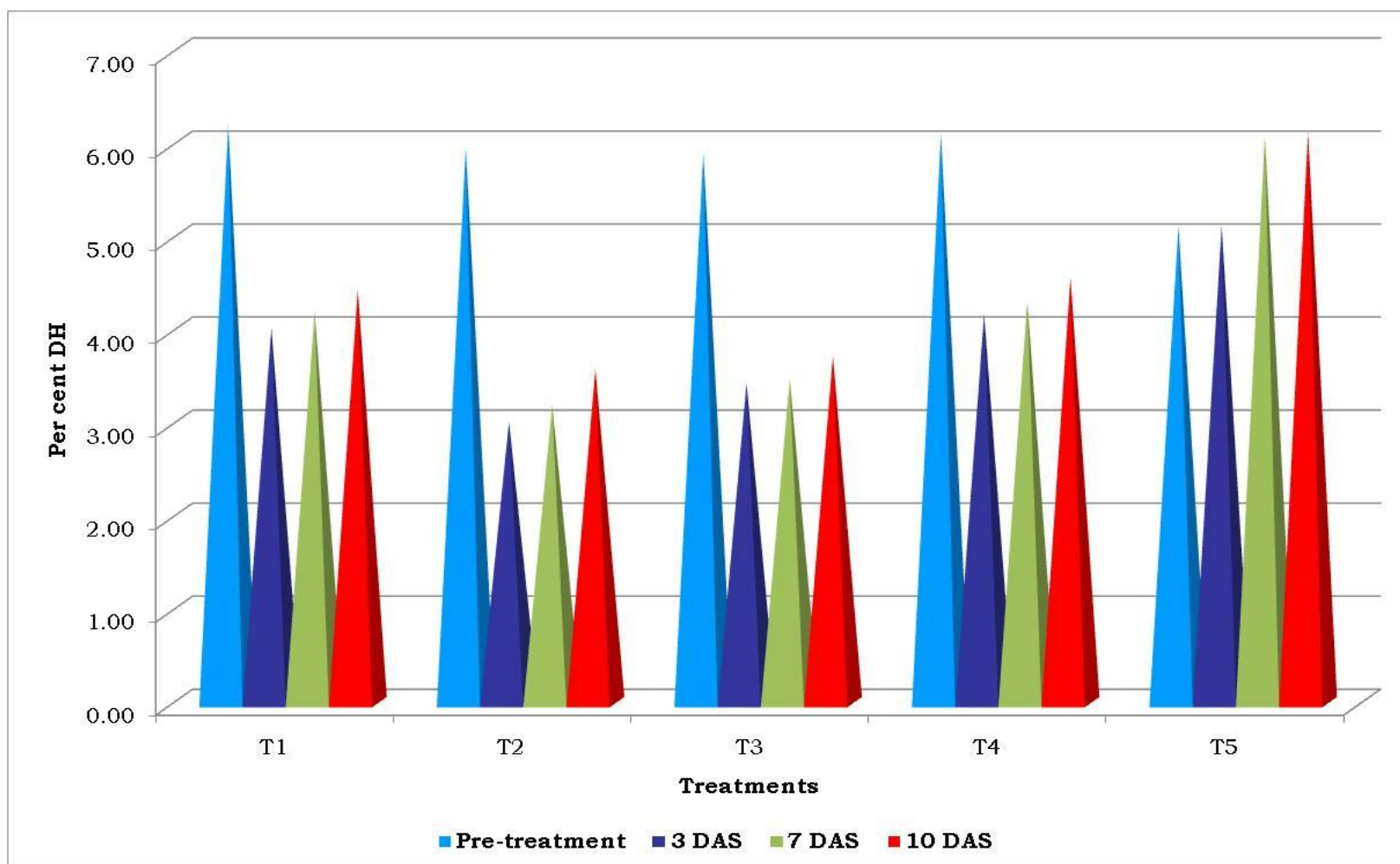


Fig. 26: Effectiveness of insecticides against rice yellow stem borer after first spray during *kharif* 2012

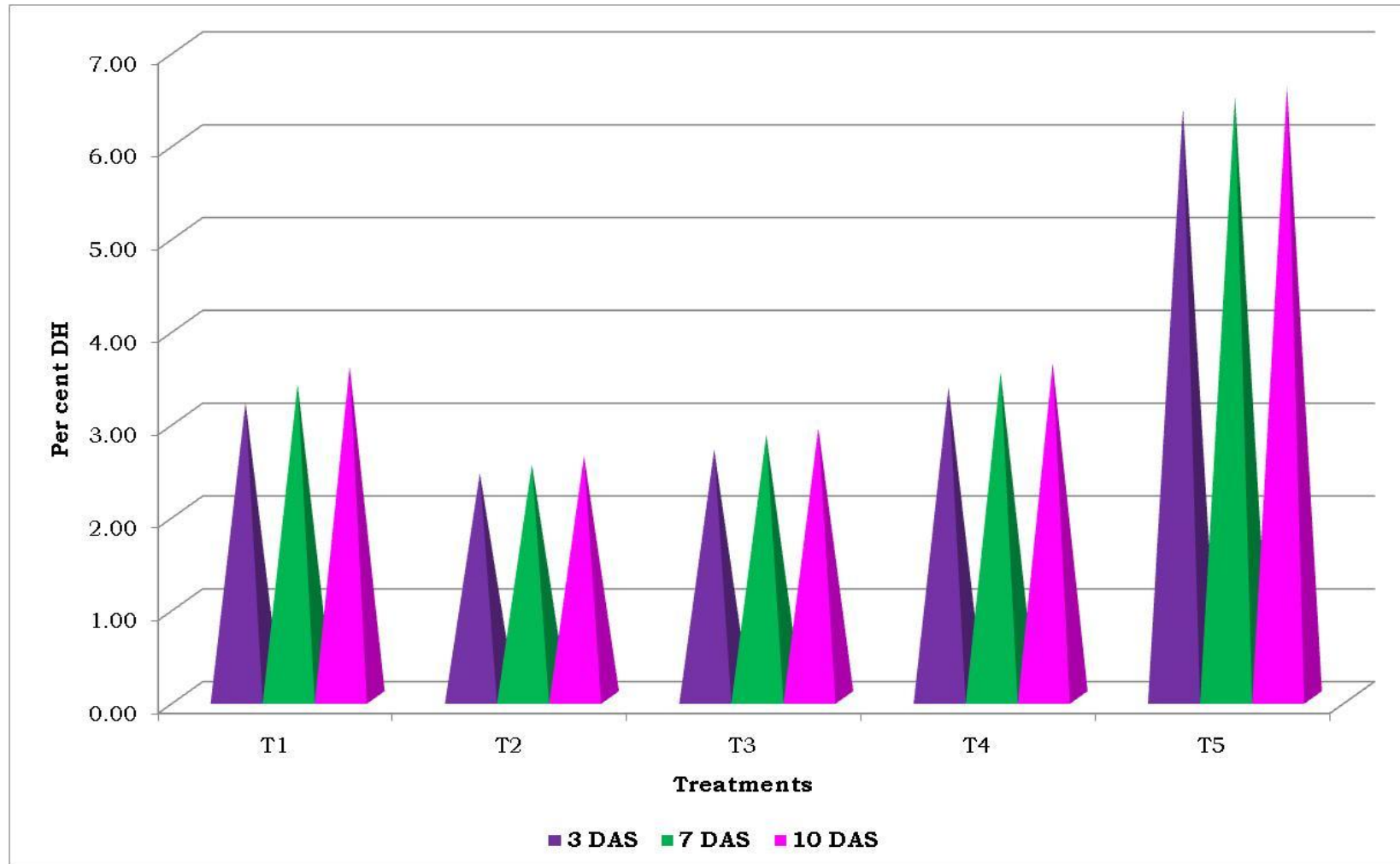


Fig. 27: Effectiveness of insecticides against rice yellow stem borer after second spray during *kharif* 2012

ii. At 7 DAS:

The similar trend of insecticides performance against yellow stem borer was recorded at 7 DAS on second spray (Table 43 and Fig. 27) and showed significant results. The lowest dead heart count was found in (T₂) fipronil 0.3 G (2.51%), followed by spinosad 45 SC (T₃) (2.83%) and were at par with each other. The next best treatments were profenophos 50 EC (T₁) (3.38%) and cartap hydrochloride (T₄) (3.51%), which were found comparable with each other. The highest dead heart damage of 6.47% was observed in control plot (T₅).

iii. At 10 DAS:

The performance of insecticides at 10 DAS showed similar trend against yellow stem borer and showed significant results (Table 43 and Fig. 27). The minimum damage was recorded fipronil 0.3 G (T₂) (2.61%), followed by spinosad 45 SC (T₃) (2.90%) and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) recorded 3.57 and 3.60% dead hearts, which were at par with each other and also showed significantly lower damage over control (6.12%). The infestation in control showed increasing trend in successive days from 3 DAS to 10 DAS as no management application was undertaken in this plot.

4.3.2. Second Year (Kharif 2013):**a. First spray:****i. Pre-treatment:**

The results of different insecticides used against yellow stem borer management during *Kharif* 2013 at before spraying of first spray showed non-significant results (Table 44 and Fig. 27). This indicated the infestation was equally distributed in the treatment plots.

ii. At 3 DAS:

The data on per cent dead heart due to yellow stem borer at 3 days after first spray (Table 44 and Fig. 28) evidenced significant results,

where fipronil 0.3 G (T₂) showed lowest 3.09% dead hearts and found superior among all insecticides, but was at par with spinosad 45 SC (T₃) (3.34%). The next best treatment was profenophos 50 EC (T₁), which recorded 4.18% dead hearts and found at par with cartap hydrochloride (T₄) with 4.35% dead hearts. The highest dead hearts of 5.98% was found in control plot (T₅).

iii. At 7 DAS:

The trend of insecticides performance against yellow stem borer recorded at 7 DAS on first spray was also showed similar type as observed as 3 DAS. (Table 44 and Fig. 28). The data showed significant results, where lowest dead hearts of 3.23% were found in plots treated with fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃) (3.44%) and they were at par with each other. The next best treatments were profenophos 50 EC (T₁) (4.36%) and cartap hydrochloride (T₄) (4.51%) and showed at par results with each other. The highest dead heart damage of 6.15% was found in control plot (T₅).

iv. At 10 DAS:

At 10 DAS, the data of insecticides against yellow stem borer showed significant results (Table 44 and Fig. 28). The minimum damage was found in spinosad 45 SC (T₃) (3.69%), followed by fipronil 0.3 G (T₂) (3.75%) and they were like with each other. The next treatments *viz.*, profenophos 50 EC (T₁) (4.78%) and cartap hydrochloride (T₄) (5.05%) also showed significantly lower damage over control (6.23%), but previous two were at par with each other.

b. Second spray:

i. At 3 DAS:

The percentage dead hearts due to yellow stem borer at 3 DAS after second spray (Table 44 and Fig. 29) revealed significant results and fipronil 0.3 G (T₂) recorded lowest 2.37% dead hearts and found superior among all insecticides, but was at par with spinosad 45 SC (T₃) (2.70%). The next best treatment was profenophos 50 EC (T₁), which

recorded 3.36% dead hearts and showed at par results with cartap hydrochloride (T₄) (3.43%). The highest dead heart damage of 6.07% was observed in control plot (T₅).

Table 44: Effectiveness of insecticides against rice yellow stem borer after during Kharif 2013

Sr. No.	Treatments	Before spray	% DH after first spray			% DH after second spray		
			3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
1.	Profenophos 50 EC	13.88 (5.81)	11.77 (4.18)	12.00 (4.36)	12.60 (4.78)	10.54 (3.36)	10.64 (3.42)	10.83 (3.55)
2.	Fipronil 0.3 G	14.18 (6.09)	10.08 (3.09)	10.30 (3.23)	11.13 (3.75)	8.81 (2.37)	9.33 (2.64)	9.19 (2.57)
3.	Spinosad 45 SC	14.41 (6.25)	10.51 (3.34)	10.65 (3.44)	11.01 (3.69)	9.43 (2.70)	9.61 (2.80)	9.55 (2.77)
4.	Cartap hydrochloride 4 G	14.02 (5.91)	12.03 (4.35)	12.23 (4.51)	12.97 (5.05)	10.65 (3.43)	10.83 (3.56)	11.15 (3.77)
5.	Control (water)	14.08 (5.96)	14.13 (5.98)	14.34 (6.15)	14.44 (6.23)	14.24 (6.07)	14.34 (6.15)	14.24 (6.06)
S. E. (m) _±		0.69	0.34	0.43	0.44	0.35	0.33	0.33
C. D. at 5%		NS	1.01	1.27	1.31	1.04	0.96	0.98
C. V.		11.71	7.16	8.84	8.72	8.06	7.28	7.41
* Values in outside the parentheses are arc sine transformed values and inside are original values.								

ii. At 7 DAS:

The similar type of performance trend of insecticides against yellow stem borer was recorded at 7 days after second spray and showed significant results (Table 44 and Fig. 29). The lowest dead hearts were found fipronil 0.3 G (T₂) with 2.64%, followed by 2.80% in spinosad 45 SC (T₃) and they were at par with each other. The next best treatments were profenophos 50 EC (T₁) (3.42%) and cartap hydrochloride (T₄)

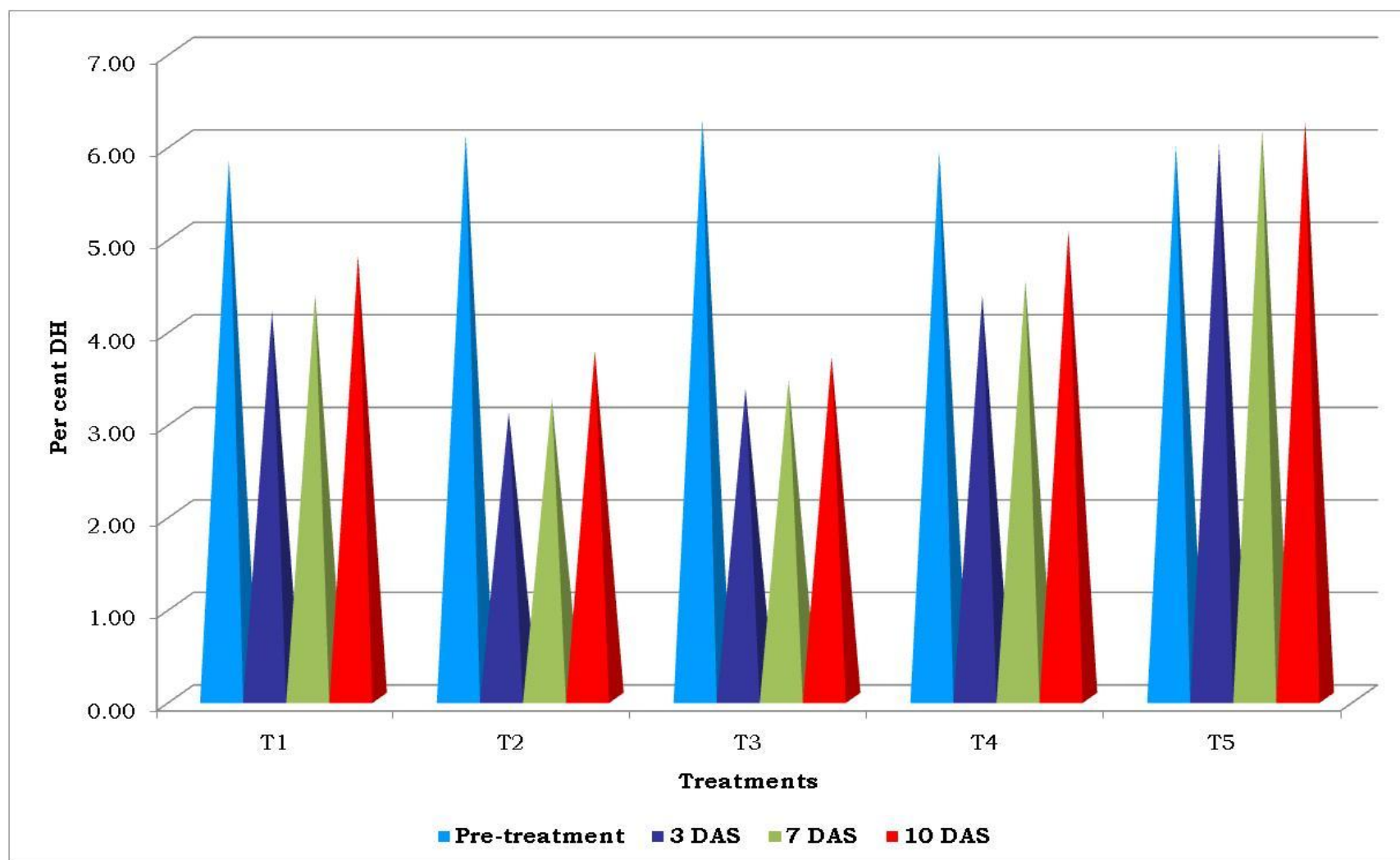


Fig. 28: Effectiveness of insecticides against rice yellow stem borer after first spray during *kharif* 2013

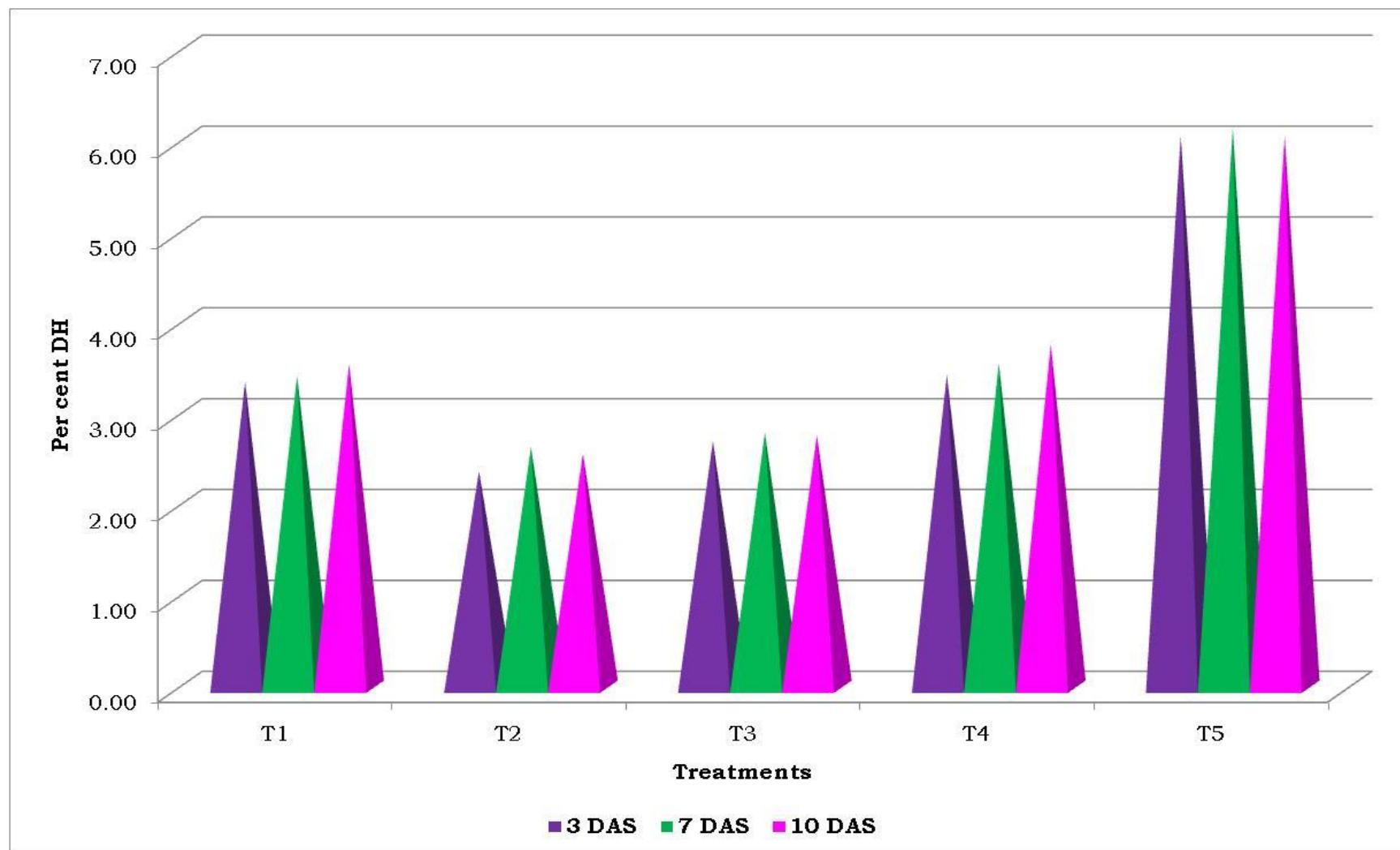


Fig. 29: Effectiveness of insecticides against rice yellow stem borer after second spray during *kharif* 2013

(3.56%) and found at par with each other. The highest dead heart damage of 6.15% was observed in control plot (T₅).

iii. At 10 DAS:

The data recorded at 10 DAS after second spray showed significant results and the trend of insecticides performance against yellow stem borer was similar as earlier at 7 DAS (Table 44 and Fig. 29). The minimum damage was recorded fipronil 0.3 G (T₂) (2.57%), followed by spinosad 45 SC (T₃) (2.77%) and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) (3.55%) and cartap hydrochloride (T₄) (3.77%) also showed significantly lower damage over control (6.12%), but previous two were at par with each other. The infestation in control showed increasing trend in successive days.

4.3.3 Two years pooled:

a. First spray:

i. Pre-treatment:

The performance of different insecticides against yellow stem borer management at first spray before spraying showed non-significant results indicating there were no differences among treatments (Table 45 and Fig. 30). The interaction effect between treatments and year was non-significant.

ii. At 3 DAS:

The data on per cent dead hearts due to yellow stem borer at 3 DAS on first spray (Table 45 and Fig. 30) revealed significant results and fipronil 0.3 G (T₂) with 3.05% dead hearts found superior among all insecticides, but was at par with spinosad 45 SC (T₃) (3.39%). The next best treatment was profenophos 50 EC (T₁) which recorded 4.10% dead heart and found at par with cartap hydrochloride (T₄) (4.26%). The highest dead hearts damage of 5.55% was observed in control plot (T₅). The interaction effect between treatments and year was non-significant, which revealed consistent performance of insecticides during the period of both years.

iii. At 7 DAS:

The parallel trend on performance of insecticides against yellow stem borer was recorded at 7 DAS on first spray (Table 45 and Fig. 30) and showed significant results. The lowest dead hearts were found in plots of fipronil 0.3 G (T₂) (3.21%), followed by spinosad 45 SC (T₃) (3.46%) and they were at par with each other. The next best treatments were profenophos 50 EC (T₁) (4.28%) and cartap hydrochloride (T₄) (4.41%) and found at par with each other. The highest dead heart damage of 6.12% was observed in control plot (T₅). The interaction effect between treatments and year was non-significant.

iv. At 10 DAS:

At 10 DAS on first spray, the similar trend insecticides efficacy against yellow stem borer was found with significant findings (Table 45 and Fig. 30). The minimum damage was recorded in treatment fipronil 0.3 G (T₂) (3.66%), followed by spinosad 45 SC (T₃) (3.70%) and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) (4.61%) and cartap hydrochloride (T₄) (4.81%) also showed significantly lower damage over control (6.17%), but previous two were found at par with each other. The interaction effect between treatments and year was non-significant, which revealed consistent performance of insecticides during the period of both years.

b. Second spray:**i. At 3 DAS:**

The per cent dead hearts due to yellow stem borer at 3 DAS on second spray (Table 45 and Fig. 31) revealed significant results and fipronil 0.3 G (T₂) with 2.40% dead hearts found superior among all insecticides, but was at par with spinosad 45 SC (T₃) (2.69%). The next best treatment was profenophos 50 EC (T₁), which recorded 3.27% dead hearts and showed at par results with cartap hydrochloride (T₄) (3.39%). The highest dead heart damage of 6.02% was observed in control plot

(T₅). The interaction effect between treatments and year was non-significant.

Table 45: Effectiveness of insecticides against rice yellow stem borer (Two years pooled)

Sr. No.	Treatments	Before spray	% DH after first spray			% DH after second spray		
			3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
1.	Profenophos 50 EC	14.13 (6.01)	11.66 (4.10)	11.91 (4.28)	12.37 (4.61)	10.40 (3.27)	10.60 (3.40)	10.85 (3.56)
2.	Fipronil 0.3 G	14.10 (6.02)	10.03 (3.05)	10.28 (3.21)	11.00 (3.66)	8.85 (2.40)	9.20 (2.57)	9.21 (2.59)
3.	Spinosad 45 SC	14.20 (6.08)	10.59 (3.39)	10.67 (3.46)	11.06 (3.70)	9.41 (2.69)	9.64 (2.81)	9.67 (2.84)
4.	Cartap hydrochloride 4 G	14.16 (6.01)	11.91 (4.26)	12.09 (4.41)	12.64 (4.81)	10.59 (3.39)	10.79 (3.53)	11.04 (3.68)
5.	Control (water)	13.57 (5.54)	13.59 (5.55)	14.31 (6.12)	14.34 (6.17)	14.41 (6.20)	14.54 (6.31)	14.54 (6.32)
S. E. (m) _± (T)		0.4	0.23	0.27	0.27	0.22	0.21	0.22
C. D. at 5% (T)		NS	0.64	0.77	0.78	0.62	0.60	0.64
S. E. (m) _± (YxT)		0.57	0.32	0.40	0.40	0.32	0.31	0.33
C. D. at 5% (YxT)		NS	NS	NS	NS	NS	NS	NS
C. V.		10.01	6.77	8.23	7.95	7.24	6.89	7.21
* Values in outside the parentheses are arc sine transformed values and inside are original values.								

ii. At 7 DAS:

The similar type of trend on performance of insecticides against yellow stem borer was recorded at 7 DAS on second spray and showed significant findings (Table 45 and Fig. 31). The lowest dead heart count was found fipronil 0.3 G (T₂) (2.57%), followed by spinosad 45 SC (T₃) (2.81%) and showed at par results with each other. The next best treatments were profenophos 50 EC (T₁) (3.40%) and cartap hydrochloride (T₄)

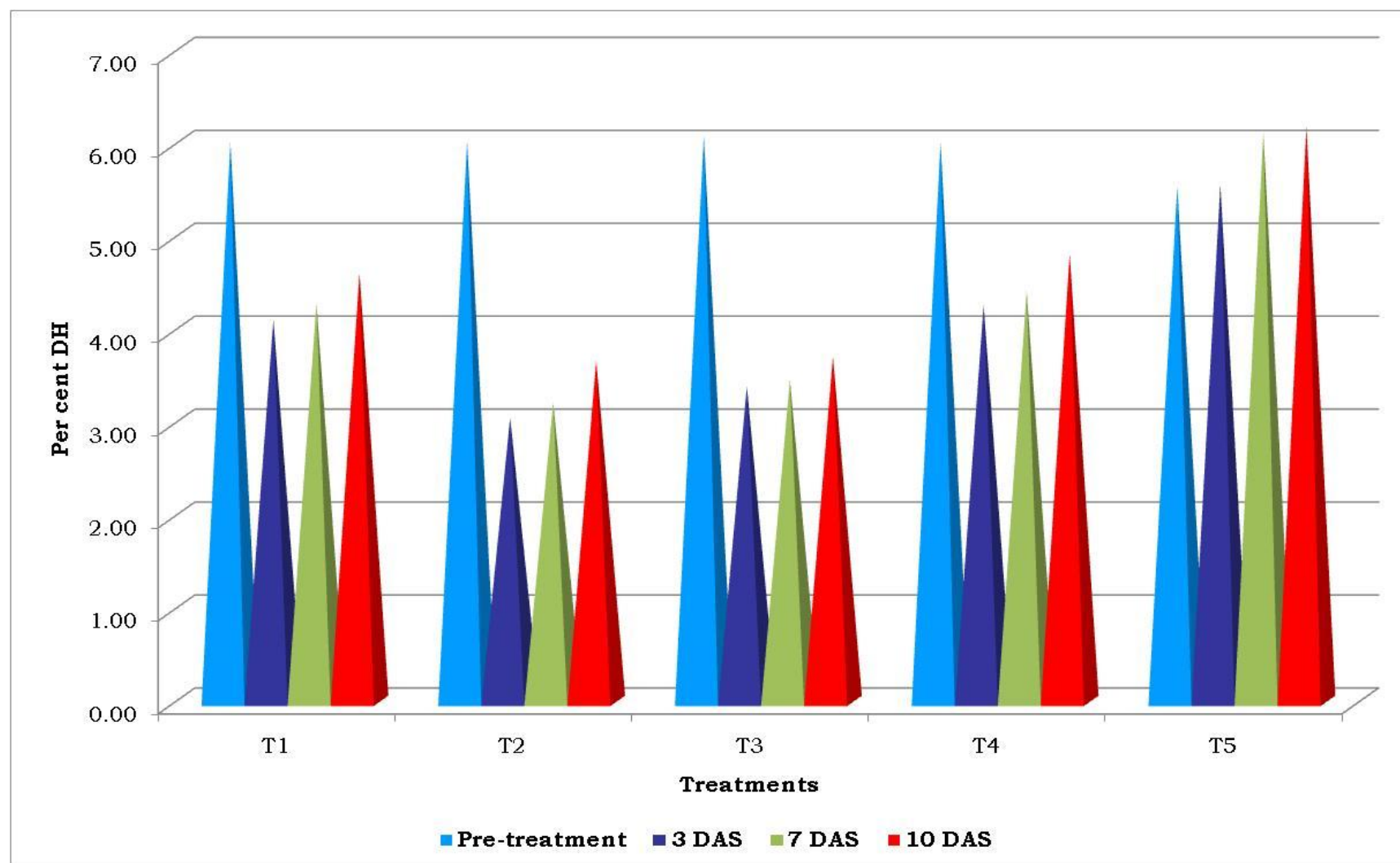


Fig. 30: Effectiveness of insecticides against rice yellow stem borer after first spray (Two years pooled)

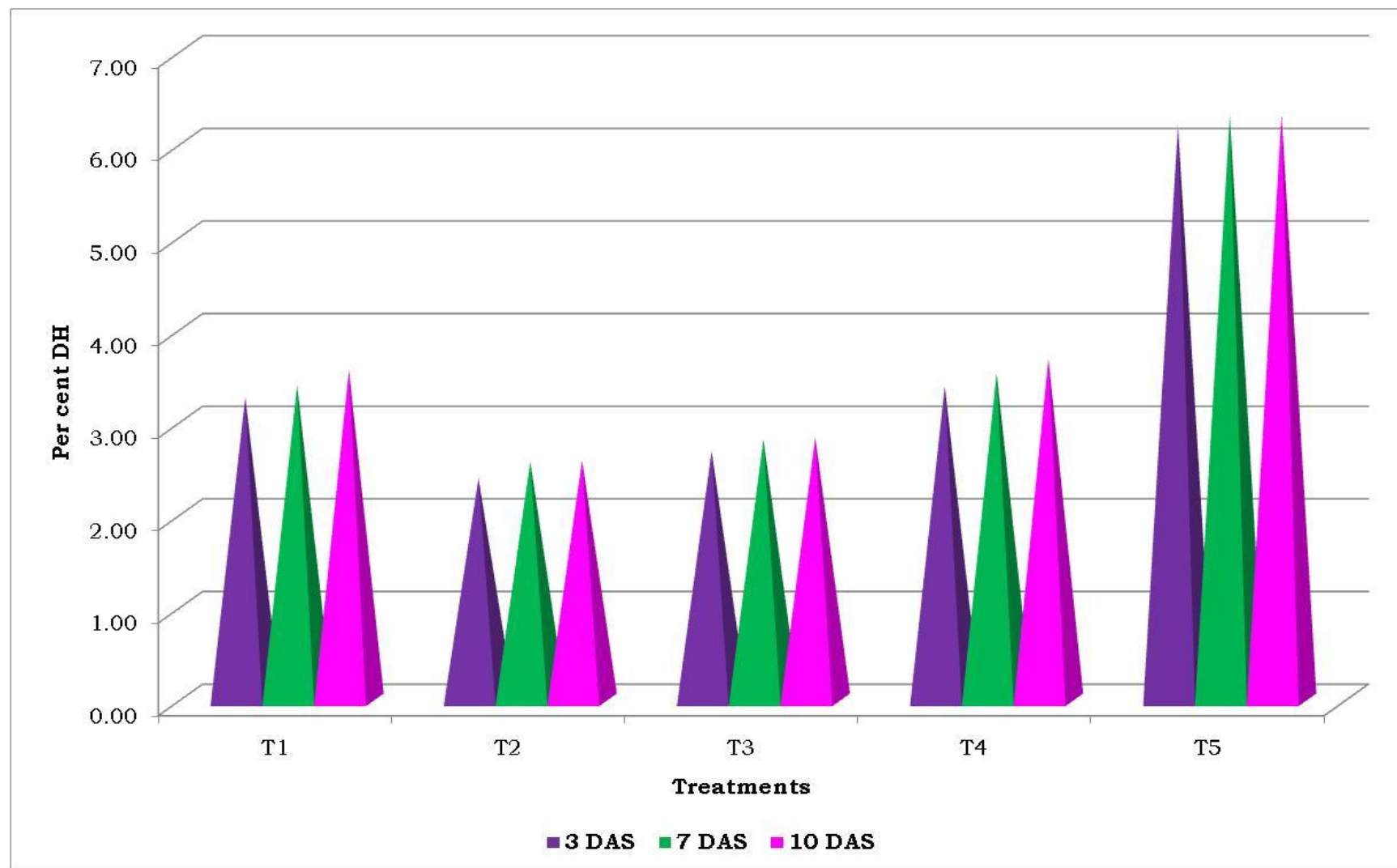


Fig. 31: Effectiveness of insecticides against rice yellow stem borer after second spray (Two years pooled)

(3.53%) and found at par with each other. The highest dead heart damage of 6.31% was observed in control plot (T₅). The interaction effect between treatments and year was non-significant indicating consistent show of insecticides during the period of both years.

iii. At 10 DAS:

At 10 DAS, the similar trend of insecticides performance against yellow stem borer was observed with significant data (Table 45 and Fig. 31). The minimum damage was recorded fipronil 0.3 G (T₂) (2.59%), followed by spinosad 45 SC (T₃) (2.84%) and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) (3.56%) and cartap hydrochloride (T₄) (3.68%) were at par with each other and also showed significantly lower damage over control (6.32%). The interaction effect between treatments and year was non-significant, which revealed consistent performance of insecticides during the period of both years.

Fipronil 5 SC reported as the most effective insecticide by Sontake and Dash (2000), Panda *et al.* (2004), Kuttalum *et al.* (2008), Dash and Mukherjee (2003), Sekh *et al.* (2007), Desai (2008), Dhaka *et al.* (2009), Hugar *et al.* (2009) and Hugar *et al.* (2010) which was also found superior in present investigation and therefore these findings match with the current study match with earlier findings.

Some other worker like Singh *et al.* (2010) revealed that cartap hydrochloride 4G and fipronil 0.3 were comparatively more effective, while Kumar and Sachan (2011) tested five newer and among biopesticide, a new molecule spinosad @ 200 ml a.i./ha was found more effective. Similarly, in the investigation of Karthikeyan *et al.* (2008), who showed that spinosad @ 54 g a.i./ha caused higher reduction in dead hearts and white ears. These above studies strongly support the present experimental results.

According to Ibrar and Manzoor (1983), Mo *et al.* (1983), Peter and David (1988), Khan and Khaliq (1989), Saljoqui *et al.* (2002), Lal (2006) and Bhutto and Soomro (2009) who recorded the lowest stem borer

incidence in cartap hydrochloride treated plots, but in the present study cartap hydrochloride 4 G was fourth best treatment. Similarly Gole (2012) proved that cartap hydrochloride 4 G also registered lower dead hearts than fipronil 5 SC and profenophos 40% + cypermethrin 4% EC. This might be due to the development of resistant or due to its comparison with highly effective molecules with different mode of action under the present study.

4.3.4 Yield:

The data on yield of paddy obtained during *Kharif* 2012 and *Kharif* 2013 under influence of various insecticidal treatments are analysed and presented in Table 46 and depicted graphically in Fig. 32.

i. First Year (*Kharif* 2012)

The yield data collected after management of yellow stem borer by using different insecticides recorded significant results (Table 46 and Fig. 32). The highest yield of 59.42 q/ha was recorded in treatment of fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃) with 57.75 q/ha yield and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) recorded 52.42 and 51.58 q/ha yield, which were found at par with each other and also showed significantly higher yield over control (44.67 q/ha).

ii. Second Year (*Kharif* 2013):

The yield data collected after management of yellow stem borer by using different insecticides recorded significant results (Table 46 and Fig. 32). The highest yield of 58.67 q/ha was observed in treatment of fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃) with 56.67 q/ha yield and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) recorded 51.00 and 49.08 q/ha yield, which were found at par with each other and also showed significantly higher yield over control (42.92 q/ha).

Table 46: Effectiveness of insecticides on yield (q/ha) of rice during Kharif 2012, Kharif 2013 and pooled

Sr. No.	Treatments	Yield (q/ha)		
		Kharif 2012	Kharif 2013	Pooled
1.	Profenophos 50 EC	52.42	51.00	51.71
2.	Fipronil 0.3 G	59.42	58.67	59.04
3.	Spinosad 45 SC	57.75	56.67	57.21
4.	Cartap hydrochloride 4G	51.58	49.08	50.33
5.	Control (water)	44.67	42.92	43.79
S. E. (m)± (T)		1.75	1.82	1.21
C. D. at 5% (T)		5.17	5.36	3.44
S. E. (m)± (YxT)		--	--	1.78
C. D. at 5% (YxT)		--	--	NS
C. V.		8.07	8.61	8.34

iii. pooled data :

The pooled data on yield obtained after management of yellow stem borer by using different insecticides showed significant findings (Table 46 and Fig. 32). The highest yield of 59.04 q/ha was obtained in treatment fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃) with 57.21 q/ha yield and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) recorded 51.71 and 50.33 q/ha yield, which were found at par with each other and also showed significantly higher yield over control (43.79 q/ha). The interaction effect between treatments and year was non-significant indicating consistent show of insecticides during both the years.

Earlier, the higher paddy yield was recorded by the application of cartap hydrochloride (Peter and David, 1988) and fipronil (Sekh *et al.*, 2007 and Kuttalum, 2008). In the present investigation, more or less similar trend was also observed. Gole (2012) recorded higher grain yield in cartap hydrochloride 4 G than buprofezin 25 SC, fipronil 5 SC, which do not match with present findings. However, no information is available on rest of the insecticides evaluated in the present investigation and hence, results could not be compared with the work done in past.

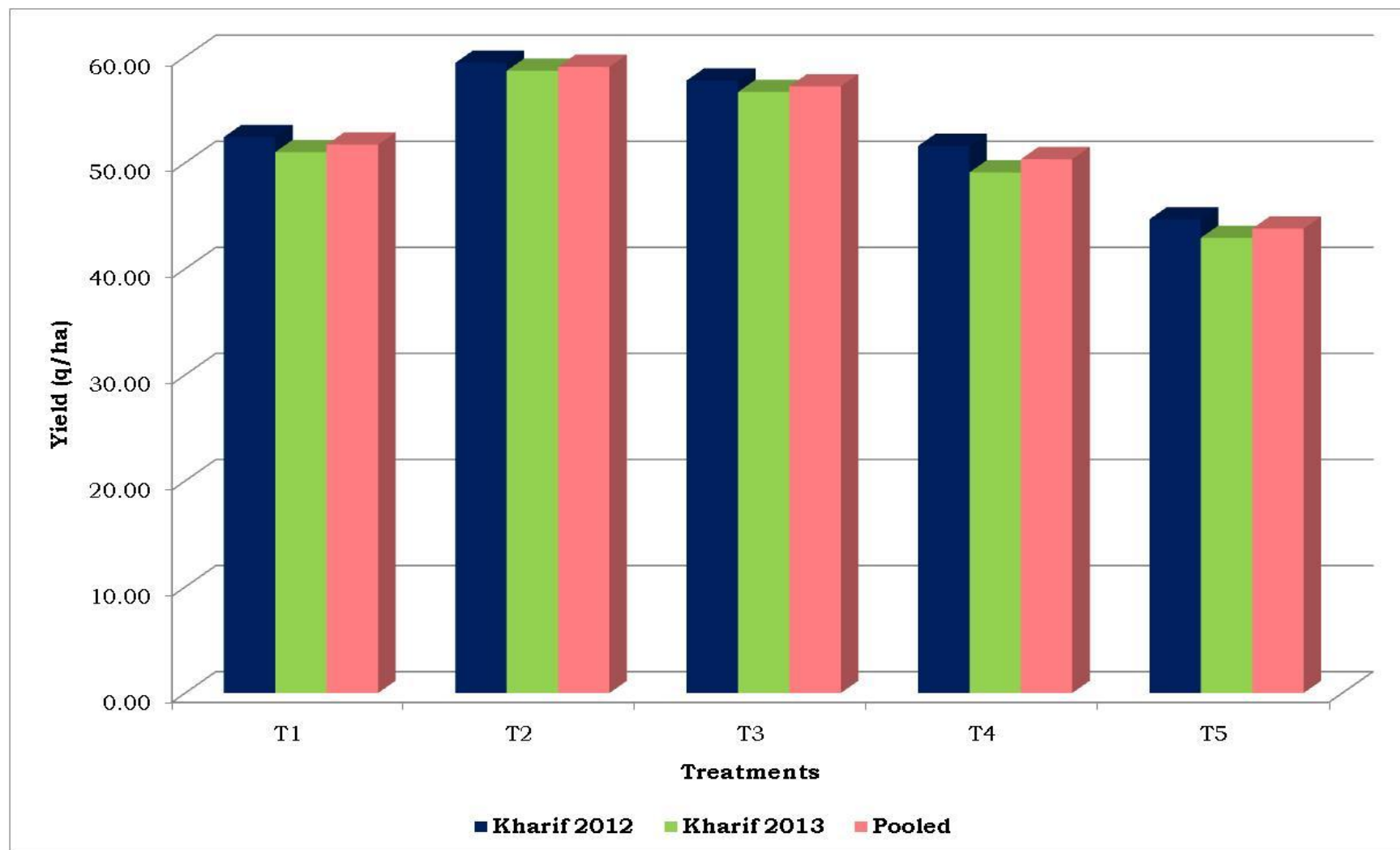


Fig. 32: Effectiveness of insecticides on yield (q/ha) of rice

4.4 Evaluation different modules for management of rice pest complex:

The data on performance of different modules comprising various IPM practices against yellow stem borer, green leaf hopper, brown plant hopper, leaf folder and blue beetle at different interval are presented in Table 47 to 53 and depicted Fig. 33 to 49.

4.4.1 Yellow stem borer (*S. incertulas*):

The result of different modules used against yellow stem borer at 30, 50, 60 and 70 days after transplanting (DAT) are presented in Table 47 and depicted Fig. 33 to 36.

a. First Year (*Kharif* 2012):

i. 30 DAT:

During *Kharif* 2012 at 30 DAT, there was significant performance among different modules against yellow stem borer (Table 47 and Fig. 33). The significantly minimum dead heart damage was recorded in Module IPM-III (chemical + non-chemical based module) (4.35%). This module was followed by Module IPM-I (chemical based module) with 5.29% dead hearts, but it was comparable with Module IPM-II (non-chemical based module) and Module IPM-IV (spot application) with 5.78 and 5.84% dead heart. The maximum damage (6.98%) was observed in Module IPM-V (farmer's practices).

ii. 50 DAT:

The dead hearts per cent due to yellow stem borer at 50 DAT (Table 47 and Fig. 34) revealed significant results among different modules and Module IPM-III (chemical + non-chemical based module) with 3.82% dead heart found superior among all modules. The next best module was Module IPM-I (chemical based module), which recorded 4.76% dead hearts and found comparable with Module IPM-II (non-chemical based module) (5.15%) and Module IPM-IV (spot application) (5.63%). The highest dead heart damage (6.76%) due to yellow stem borer was observed in Module IPM-V (farmer's practices).

iii. 60 DAT:

The similar type of trend on performance of modules against yellow stem borer was recorded at 60 DAT (Table 47 and Fig. 35) and also showed significant results. The significantly lowest dead heart (3.36%) was found in Module IPM-III (chemical + non-chemical based module). The next effective module was Module IPM-I (chemical based module) (4.27%) and it was at par with Module IPM-II (non-chemical based module) and Module IPM-IV (spot application), which recorded 4.74 and 4.78% dead hearts. The highest dead heart damage of 5.84% was observed in Module IPM-V (farmer's practices).

iv. 70 DAT:

At 70 DAT, the similar type of trend against yellow stem borer was recorded with significant results (Table 47 and Fig. 36). The minimum dead heart damage of 2.22% was recorded in Module IPM-III (chemical + non-chemical based module). The next best module was Module IPM-I (chemical based module) (2.97%) and it was comparable with other two modules *viz.*, Module IPM-II (non-chemical based module) and Module IPM-IV (spot application), which recorded 3.56 and 3.73% dead hearts and also showed significantly lower damage than Module IPM-V (farmer's practices) (5.08%).

b. Second Year (*Kharif* 2013):**i. 30 DAT:**

During *Kharif* 2013, the data on yellow stem borer damage at 30 DAT recorded significant results among different modules (Table 47 and Fig. 33). The significantly minimum dead heart damage was recorded in Module IPM-III (chemical + non-chemical based module) (4.95%). This module was followed by Module IPM-I (chemical based module) with 5.99% infestation, but similar results also found in Module IPM-II (non-chemical based module) and Module IPM-IV (spot application) with 6.28 and 6.39% dead hearts. The maximum damage (7.82%) was observed in Module IPM-V (farmer's practices).

ii. 50 DAT:

The results on dead heart per cent due to yellow stem borer at 50 DAT (Table 47 and Fig. 34) revealed significant difference, wherein Module IPM-III (chemical + non-chemical based module) found superior with 3.51% damage among other modules. The next best module was Module IPM-I (chemical based module), which recorded 4.40% dead heart and showed similar results with Module IPM-II (non-chemical based module) (4.66%) and Module IPM-IV (spot application) (5.15%). The highest dead hearts damage of 6.33% due to stem borer was observed in Module IPM-V (farmer's practices).

iii. 60 DAT:

The similar trend on performance of modules against yellow stem borer was recorded at 60 DAT (Table 47 and Fig. 35) and documented significant results. The significantly lowest dead heart (3.09%) was observed in Module IPM-III (chemical + non-chemical based module). The next effective module was Module IPM-I (chemical based module) (3.99%) and it was at par with Module IPM-II (non-chemical based module) and Module IPM-IV (spot application), which recorded 4.28 and 4.49% dead hearts. The highest dead heart damage of 5.80% was found in Module IPM-V (farmer's practices).

iv. 70 DAT:

Similarly at 70 DAT, the analogous trend in modules performance against yellow stem borer was found with significant results (Table 47 and Fig. 36). The significantly minimum dead heart damage of 2.03% was recorded in Module IPM-III (chemical + non-chemical based module). The next best module was Module IPM-I (chemical based module) (2.80%) and it was found comparable with Module IPM-II (non-chemical based module) (3.45%), followed by Module IPM-IV (spot application) (3.54%), which also showed significantly lower damage than Module IPM-V (farmer's practices) (4.58%). But, Module IPM-II and Module IPM-IV were found at par with each other.

Table 47: Evaluation of modules against rice yellow stem borer at vegetative and heading stage during *Kharif* 2012 and *Kharif* 2013

Sr. No.	Name of module	% DH at 30 DAT			% DH at 50 DAT			% WEH at 60 DAT			% WEH at 70 DAT		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
1.	Module IPM-I (Chemical based module)	13.27 (5.29)	14.13 (5.99)	13.70 (5.64)	12.57 (4.76)	12.08 (4.40)	12.33 (4.58)	11.92 (4.27)	11.51 (3.99)	11.72 (4.13)	9.89 (2.97)	9.59 (2.80)	9.74 (2.88)
2.	Module IPM -II (Non-chemical based module)	13.87 (5.78)	14.47 (6.28)	14.17 (6.03)	13.08 (5.15)	12.43 (4.66)	12.75 (4.91)	12.48 (4.74)	11.83 (4.28)	12.15 (4.51)	10.76 (3.56)	10.62 (3.45)	10.69 (3.51)
3.	Module IPM -III (Chemical + Non-chemical based module)	12.01 (4.35)	12.81 (4.95)	12.41 (4.65)	11.21 (3.82)	10.73 (3.51)	10.97 (3.66)	10.50 (3.36)	10.07 (3.09)	10.29 (3.23)	8.52 (2.22)	8.14 (2.03)	8.33 (2.13)
4.	Module IPM -IV (Spot application)	13.97 (5.84)	14.63 (6.39)	14.30 (6.12)	13.71 (5.63)	13.10 (5.15)	13.40 (5.39)	12.59 (4.78)	12.18 (4.49)	12.39 (4.63)	11.13 (3.73)	10.84 (3.54)	10.99 (3.64)
5.	Module IPM -V (Farmer's practices)	15.29 (6.98)	16.18 (7.82)	15.74 (7.40)	15.03 (6.76)	14.54 (6.33)	14.79 (6.54)	13.98 (5.84)	13.92 (5.80)	13.95 (5.82)	13.00 (5.08)	12.35 (4.58)	12.68 (4.83)
S. E. (m) $\pm$ (T)		0.42	0.43	0.28	0.43	0.44	0.29	0.46	0.47	0.31	0.44	0.41	0.29
C. D. at 5% (T)		1.24	1.27	0.82	1.27	1.30	0.84	1.35	1.38	0.89	1.30	1.22	0.83
S. E. (m) $\pm$ (YxT)		--	--	0.42	--	--	0.44	--	--	0.46	--	--	0.43
C. D. at 5% (YxT)		--	--	NS	--	--	NS	--	--	NS	--	--	NS
C. V.		7.53	7.29	7.40	8.02	8.61	8.31	9.09	9.60	9.35	10.15	9.82	9.98

* Values in outside the parentheses are arc sine transformed values and inside are original values.

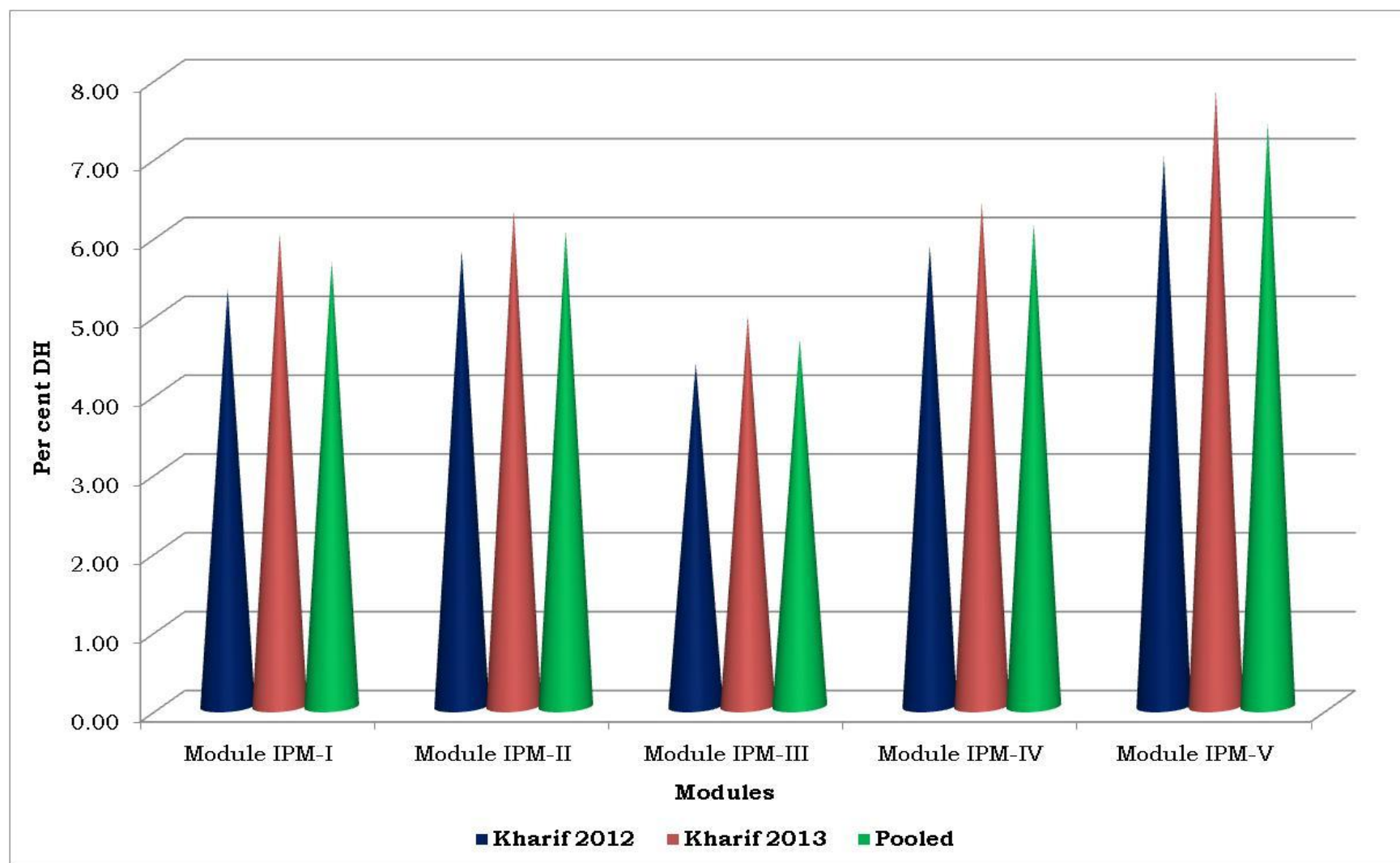


Fig. 33: Evaluation of modules against rice yellow stem borer at 30 days after transplanting

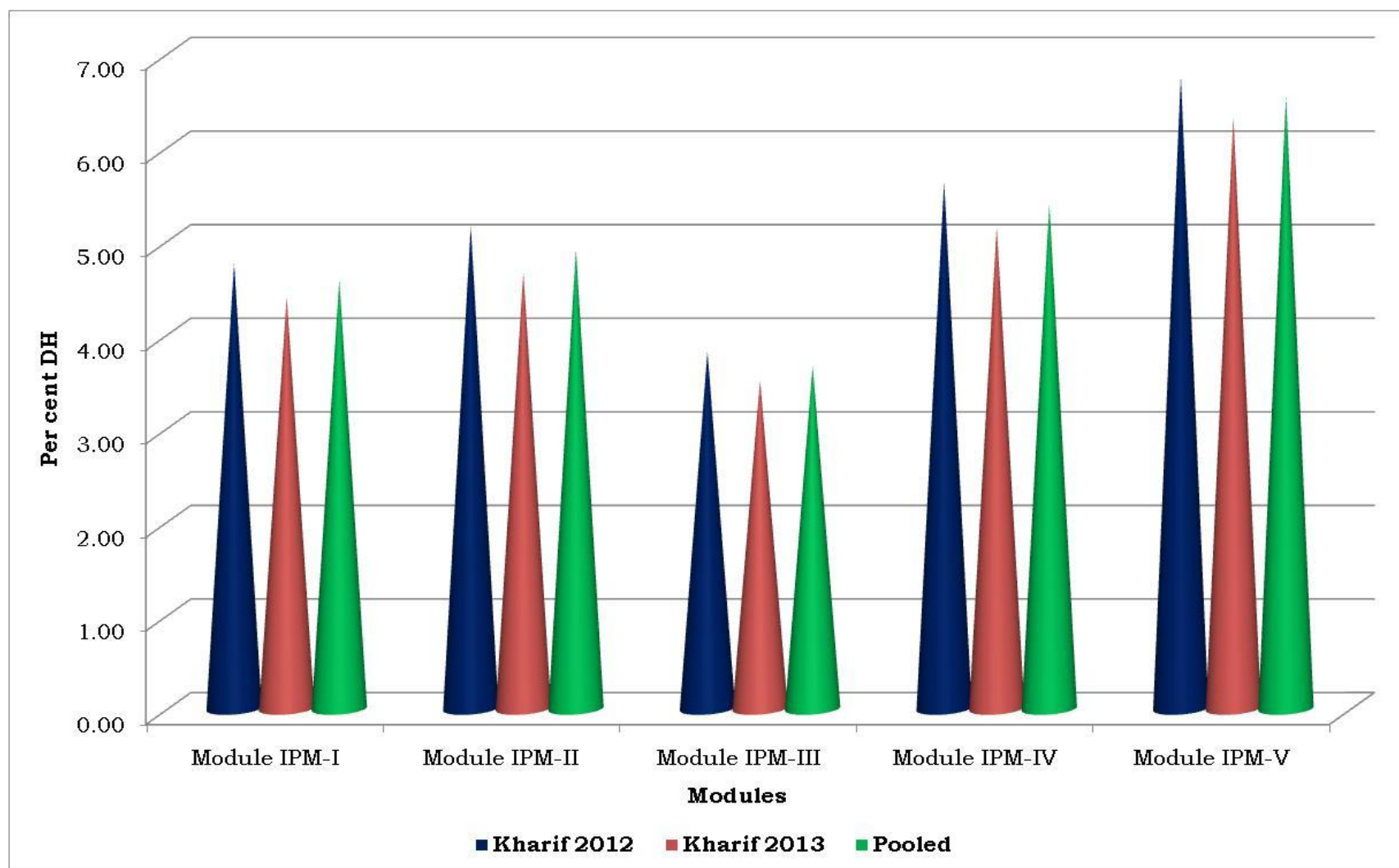


Fig. 34: Evaluation of modules against rice yellow stem borer at 50 days after transplanting

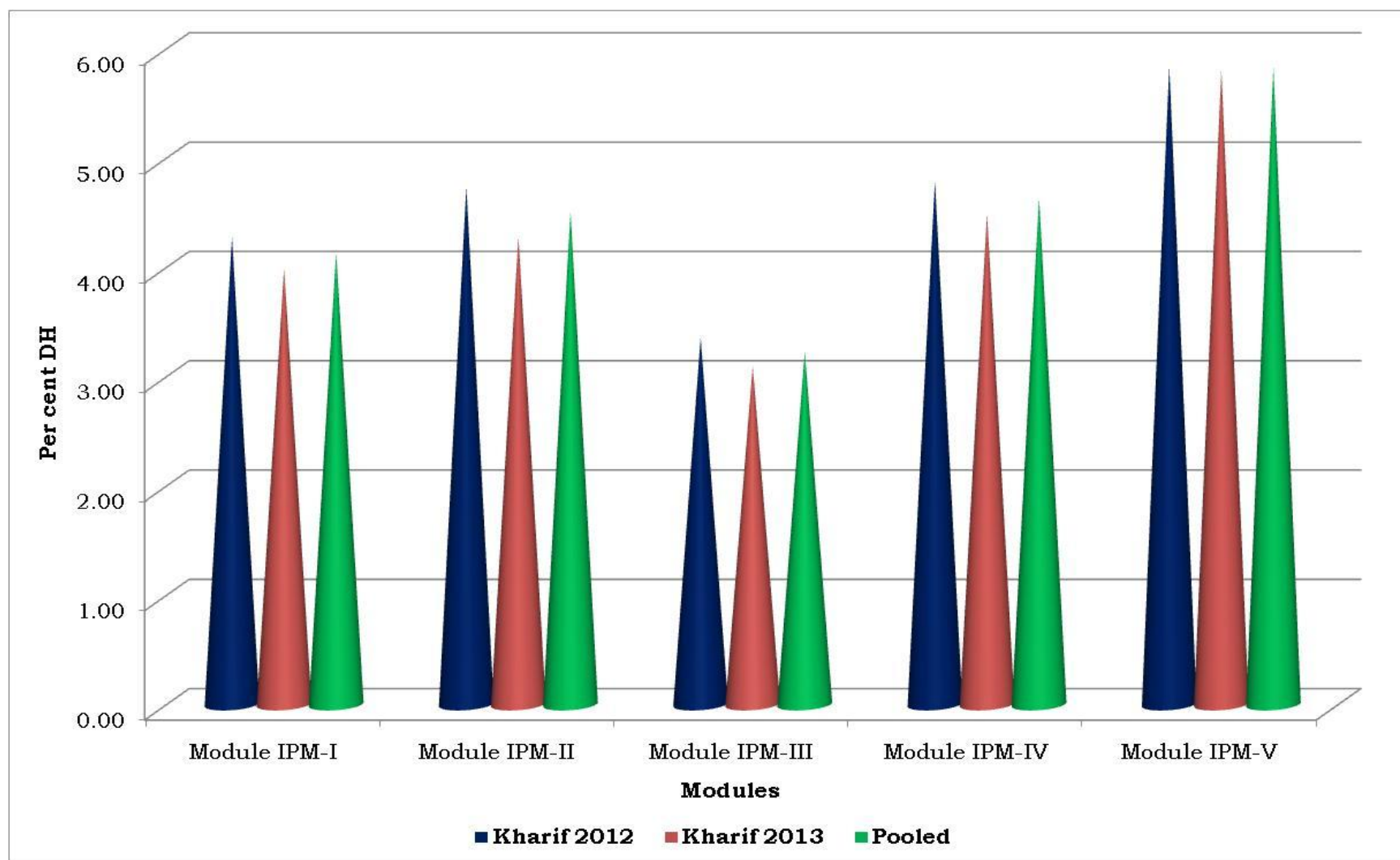


Fig. 35: Evaluation of modules against rice yellow stem borer at 60 days after transplanting

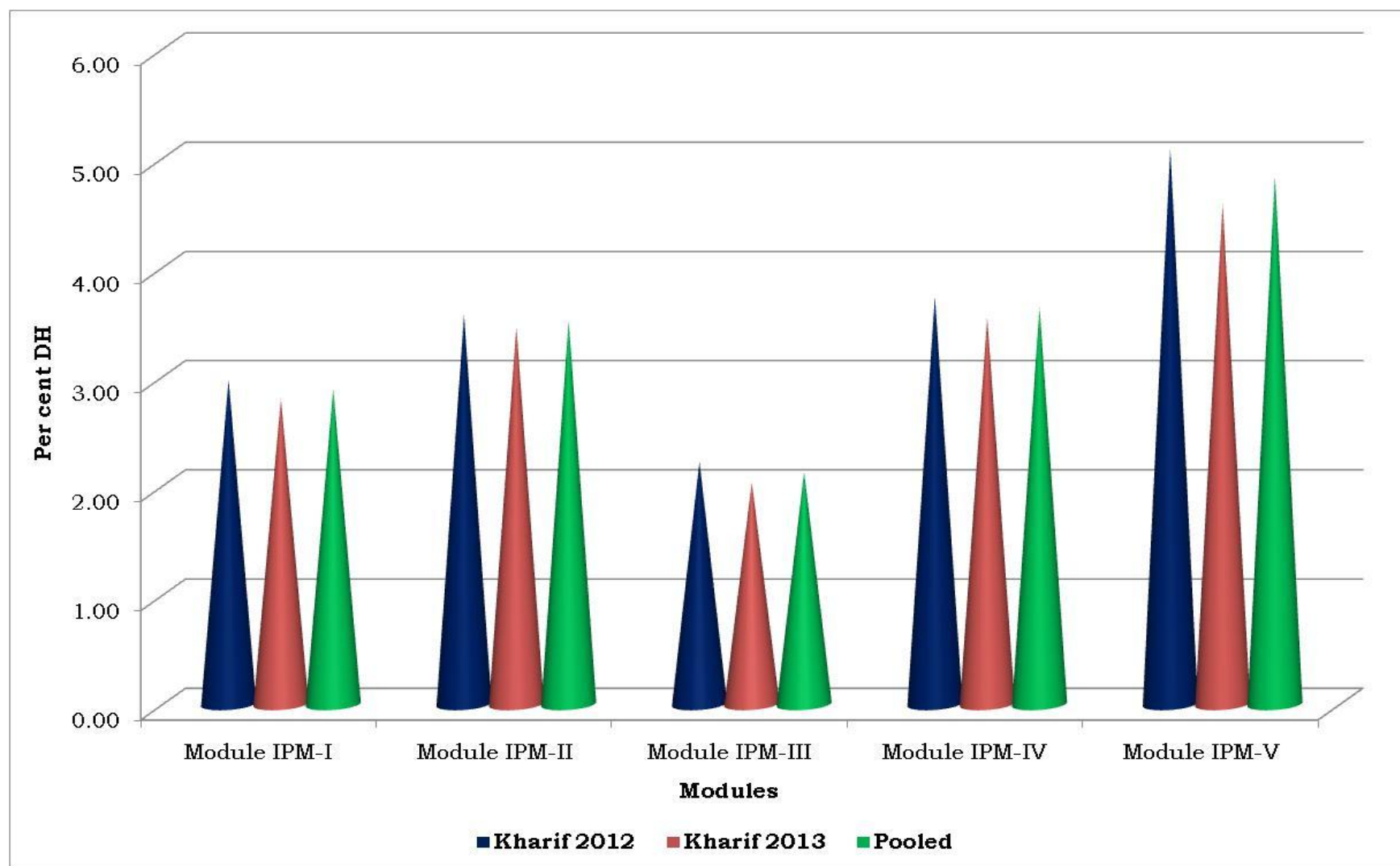


Fig. 36: Evaluation of modules against rice yellow stem borer at 70 days after transplanting



Plate No. 24: Pinning of Tricho-card to rice leaf in field under IPM Modules



Plate No. 25: Installation of pheromone trap in rice field under IPM Modules

c. Pooled data:**i. 30 DAT:**

The pooled data at 30 DAT of yellow stem borer showed significant results among the performance of different modules (Table 47 and Fig. 33). The significantly minimum dead heart damage was recorded in Module IPM-III (chemical + non-chemical based module) (4.65%). This module was followed by Module IPM-I (chemical based module) with 5.64% dead hearts, but it was comparable with Module IPM-II (non-chemical based module) and Module IPM-IV (spot application) with 6.03 and 6.12% dead heart. The maximum damage (7.40%) was observed in Module IPM-V (farmer's practices). The interaction effect between modules and year was non-significant.

ii. 50 DAT:

The pooled results on dead heart per cent due to yellow stem borer at 50 DAT (Table 47 and Fig. 34) revealed significant results and Module IPM-III (chemical + non-chemical based module) with 3.66% dead hearts found superior among other modules. The next best module was Module IPM-I (chemical based module) which recorded 4.58% dead hearts and found comparable with Module IPM-II (non-chemical based module) (4.91%) and Module IPM-IV (spot application) (5.39%). The highest dead heart damage (6.54%) due to stem borer was observed in Module IPM-V (farmer's practices). The interaction effect between modules and year was non-significant.

iii. 60 DAT:

The similar type of trend of yellow stem borer infestation was recorded at 60 DAT (Table 47 and Fig. 35) and also pooled data showed significant results among different modules. The lowest dead hearts (3.23%) was found in Module IPM-III (chemical + non-chemical based module). The next effective module was Module IPM-I (chemical based module) (4.13%) and it was at par with Module IPM-II (non-chemical based module) and Module IPM-IV (spot application), which recorded

4.51 and 4.63% dead hearts. The highest dead heart damage of 5.82% was observed in Module IPM-V (farmer's practices). The interaction effect between modules and year was non-significant.

iv. 70 DAT:

The pooled results at 70 DAT showed similar trend of modules performance against yellow stem borer with significant results (Table 47 and Fig. 36). The significantly minimum dead heart damage of 2.13% was recorded in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) (2.88%). The next effective module was Module IPM-II (non-chemical based module) and found comparable with Module IPM-IV (spot application), which recorded 3.51 and 3.64% dead hearts. The highest dead heart damage of 4.83% was recorded in Module IPM-V (farmer's practices).

The interaction effect between modules and year was found non-significant, which revealed consistent performance of module treatments during the period of both the years. However, the dead heart infestation in all IPM Module showed decreasing trend in successive period.

Earlier, various scientists validated different Integrated Pest Management (IPM) modules against yellow stem borer in rice at different locations. Among them, the results of Mohapatra (2008) revealed that IPM in basmati rice (Pusa Basmati-1) suffered with less incidence of stem borer in contrast with farmer's pest management practices and chemical based practices in which crop was more suffered with stem borer. Another field experiment was conducted on rice at Karjat showed that among the four modules, the insecticide + non insecticide based module (IPM Module III) was found superior and recorded less dead hearts at 45 and 55 DAT and also found minimum white earhead damage than insecticide based module (IPM Module I), non-insecticide based module (IPM Module II), and farmers practices (IPM Module IV) (Anonymous, 2010^c). These results match with the present investigation findings of superiority of chemical + non-chemical based module.

Similarly, Karthikeyan *et al.* (2010) conducted field experiments with 3 rice IPM modules (IPM I, IPM II and IPM III) in comparison with farmers' practices and the results showed that the IPM III module comprised alternate spraying with neem-based formulation and newer safer insecticide coupled and monitoring of stem borer with sex pheromone traps resulted in significant reduction of stem borer as compared with farmer's practices. While, Mahal *et al.* (2011) checked different Integrated Pest Management techniques for the control of stem borer and revealed that IPM model-I (Traps + chemical control) and IPM model-II (Traps + tricho-cards + chemical control) recorded lower incidence of stem borer than farmer's practices.

In another experiment, Mishra and Sharma (2012) validated IPM module against yellow stem borer in basmati rice and compared with farmer's practice (Non-IPM) during wet seasons. IPM schedule with eight components at economic threshold level showed their superiority over farmer's practices. Such types of findings also observed in present study, which proved superiority of chemical and non-chemical based IPM module.

Whereas, Dwivedi *et al.* (2007) revealed that the bio-control based IPM module with other components showed superiority over the chemical control and farmer's practice, which is comparable with the present findings of other modules.

4.4.2 Green leafhopper (*N. virescens*):

The performance of different modules followed against green leafhopper at 50, 60 and 70 DAT is presented in Table 48 and depicted Fig. 37 to 39.

a. First Year (*Kharif* 2012):

i. 50 DAT:

During first year at 50 DAT, the result of green leafhopper showed significant among different modules (Table 48 and Fig. 37). The minimum hill damage (4.27%) was recorded in Module IPM-III (chemical

+ non-chemical based module), followed by Module IPM-I (chemical based module) and Module IPM-IV (spot application) with 4.53 and 4.69% hill damage but they were found comparable with each other. The other Module IPM-II (non-chemical based module) recorded 5.55% hill damage and showed significantly lower damage over Module IPM-V (farmer's practices) (6.74%).

ii. 60 DAT:

The similar type of trend on performance of modules against green leafhopper was recorded at 60 DAT and showed significant results (Table 48 and Fig. 38). Module IPM-III (chemical + non-chemical based module) with 2.70% infestation found superior among other modules, but showed similar results with Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 2.91 and 3.10% hill damage, respectively. Module IPM-II (non-chemical based module) recorded higher hill damage (3.96%) due to green leafhoppers as compare to other modules, but found significantly effective over Module IPM-V (farmer's practices) (4.76%).

iii. 70 DAT:

The data on performance of modules against green leafhopper was recorded at 70 DAT revealed significant results (Table 48 and Fig. 39). The lowest hill damage (1.70%) was found in Module IPM-III (chemical + non-chemical based module), but found at par with Module IPM-I (chemical based module) (1.81%). The next effective module was Module IPM-IV (spot application) with 2.34% hill damage, followed by Module IPM-II (non-chemical based module) which recorded 3.06% hill infestation. The highest hill damage (3.86%) was observed in Module IPM-V (farmer's practices).

b. Second Year (*Kharif* 2013):

i. 50 DAT:

At 50 DAT during *Kharif* 2013, the result of different modules against green leafhopper was found significant (Table 48 and Fig. 37).

The minimum hill damage (4.13%) was observed in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) and Module IPM-IV (spot application) with 4.78 and 4.88% hill damage and all these three modules were found at par with each other. Module IPM-II (non-chemical based module) recorded 5.71% hill damage due to green leafhoppers and showed significantly lower damage than Module IPM-V (farmer's practices) (6.93%).

ii. 60 DAT:

The results on per cent hill damage due to green leafhopper at 60 DAT revealed significant findings among different modules and also observed similar trend of modules performance (Table 48 and Fig. 38). Module IPM-III (chemical + non-chemical based module) with 2.94% infestation found superior among other modules, but recorded parallel results with Module IPM-I (chemical based module) and Module IPM-IV (spot application), which showed 3.03 and 3.21% hill damage due to green leafhoppers. Module IPM-II (non-chemical based module) recorded higher hill damage (4.07%) as compare to other modules, but found significantly effective over Module IPM-V (farmer's practices) (5.17%).

iii. 70 DAT:

The data on modules performance against rice green leafhoppers recorded at 70 DAT showed significant results (Table 48 and Fig. 39). The lowest hill damage (1.58%) was found in Module IPM-III (chemical + non-chemical based module) and found superior among all modules, but showed at par findings with Module IPM-I (chemical based module) (1.67%). The next effective module was Module IPM-IV (spot application) with 2.22% hill damage, followed by Module IPM-II (non-chemical based module), which recorded 2.94% hill infestation due to green leafhopper. The highest hill damage of 4.75% was found in Module IPM-V (farmer's practices).

Table 48: Evaluation of modules against rice green leafhopper during *Kharif* 2012 and *Kharif* 2013

Sr. No.	Name of module	% hill damage at 50 DAT			% hill damage at 60 DAT			% hill damage at 70 DAT		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
1.	Module IPM-I (Chemical based module)	12.26 (4.53)	12.60 (4.78)	12.43 (4.66)	9.81 (2.91)	10.00 (3.03)	9.91 (2.97)	7.73 (1.81)	7.43 (1.67)	7.58 (1.74)
2.	Module IPM -II (Non-chemical based module)	13.62 (5.55)	13.82 (5.71)	13.72 (5.63)	11.45 (3.96)	11.60 (4.07)	11.52 (4.02)	10.02 (3.06)	9.83 (2.94)	9.93 (3.00)
3.	Module IPM -III (Chemical + Non-chemical based module)	11.87 (4.27)	11.69 (4.13)	11.78 (4.20)	9.41 (2.70)	9.80 (2.94)	9.61 (2.82)	7.45 (1.70)	7.18 (1.58)	7.32 (1.64)
4.	Module IPM -IV (Spot application)	12.48 (4.69)	12.74 (4.88)	12.61 (4.78)	10.14 (3.10)	10.32 (3.21)	10.23 (3.16)	8.80 (2.34)	8.56 (2.22)	8.68 (2.28)
5.	Module IPM -V (Farmer's practices)	15.03 (6.74)	15.25 (6.93)	15.14 (6.84)	12.59 (4.76)	13.14 (5.17)	12.87 (4.97)	11.31 (3.86)	12.59 (4.75)	11.95 (4.30)
S. E. (m) _± (T)		0.38	0.36	0.25	0.33	0.37	0.24	0.32	0.28	0.23
C. D. at 5% (T)		1.12	1.05	0.71	0.97	1.08	0.67	0.95	0.83	0.65
S. E. (m) _± (YxT)		--	--	0.37	--	--	0.35	--	--	0.30
C. D. at 5% (YxT)		--	--	NS	--	--	NS	--	--	NS
C. V.		7.10	6.60	6.85	7.53	8.20	7.87	8.68	7.58	8.15

* Values in outside the parentheses are arc sine transformed values and inside are original values.

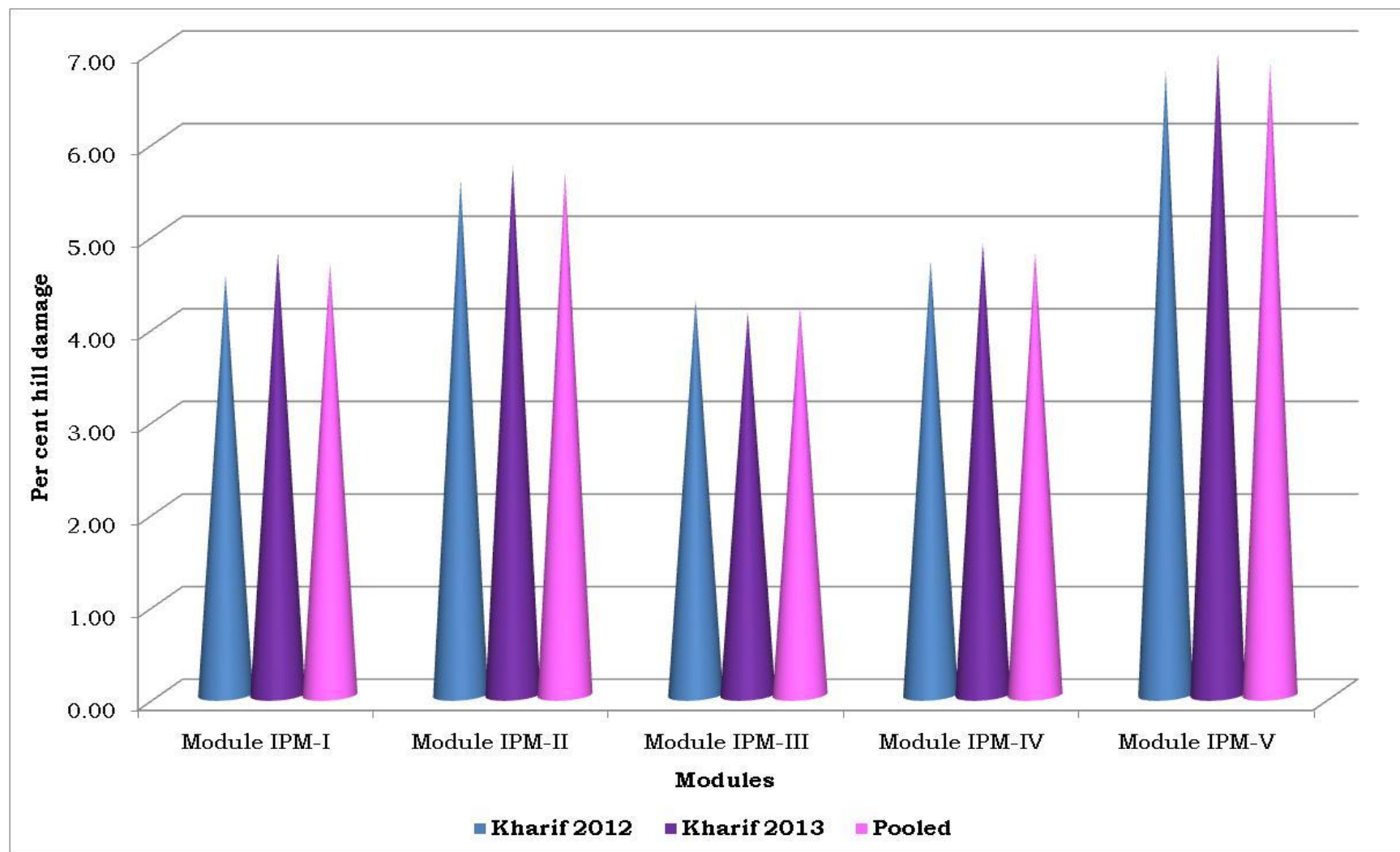


Fig. 37: Evaluation of modules against rice green leafhopper at 50 days after transplanting

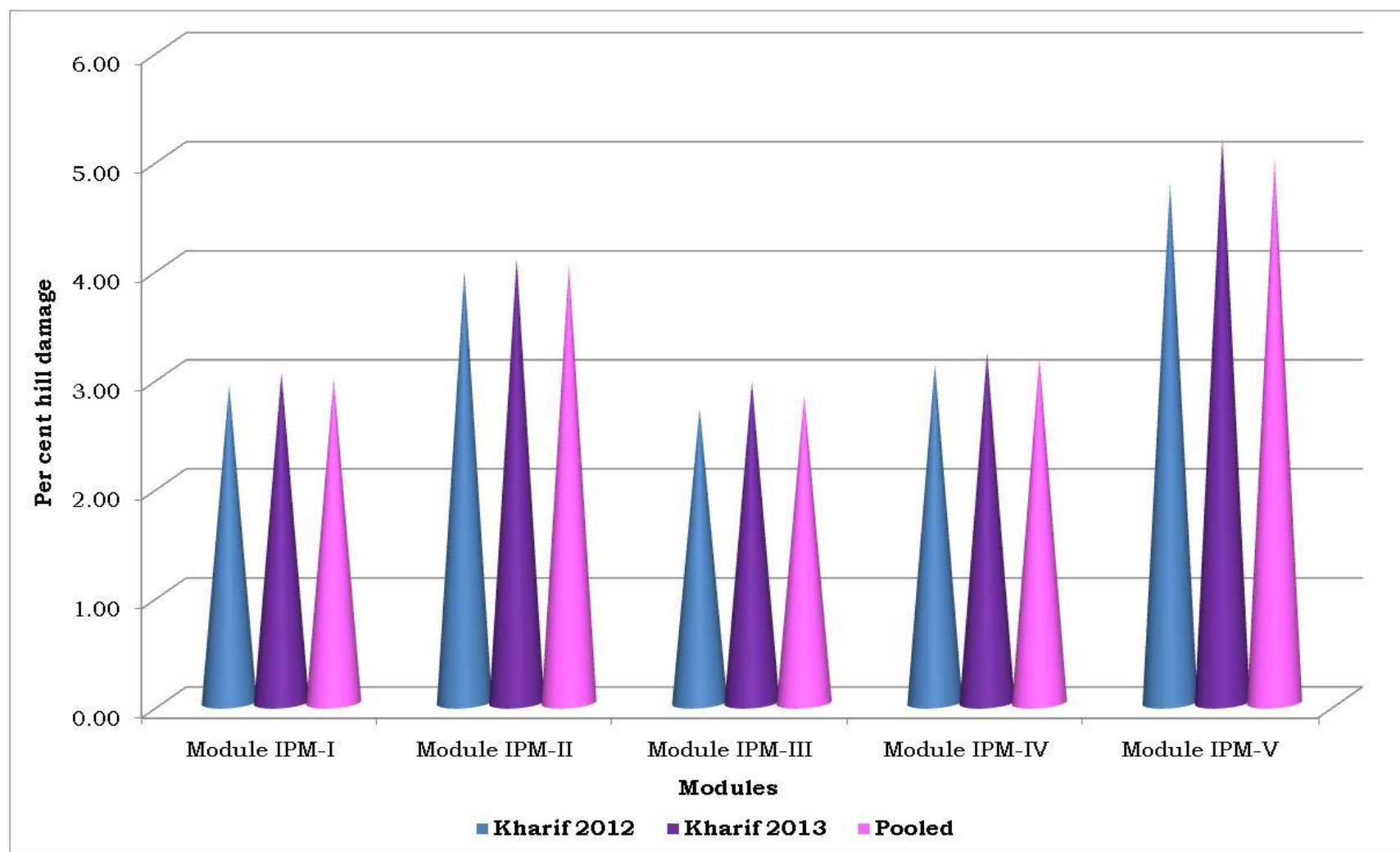


Fig. 38: Evaluation of modules against rice green leafhopper at 60 days after transplanting

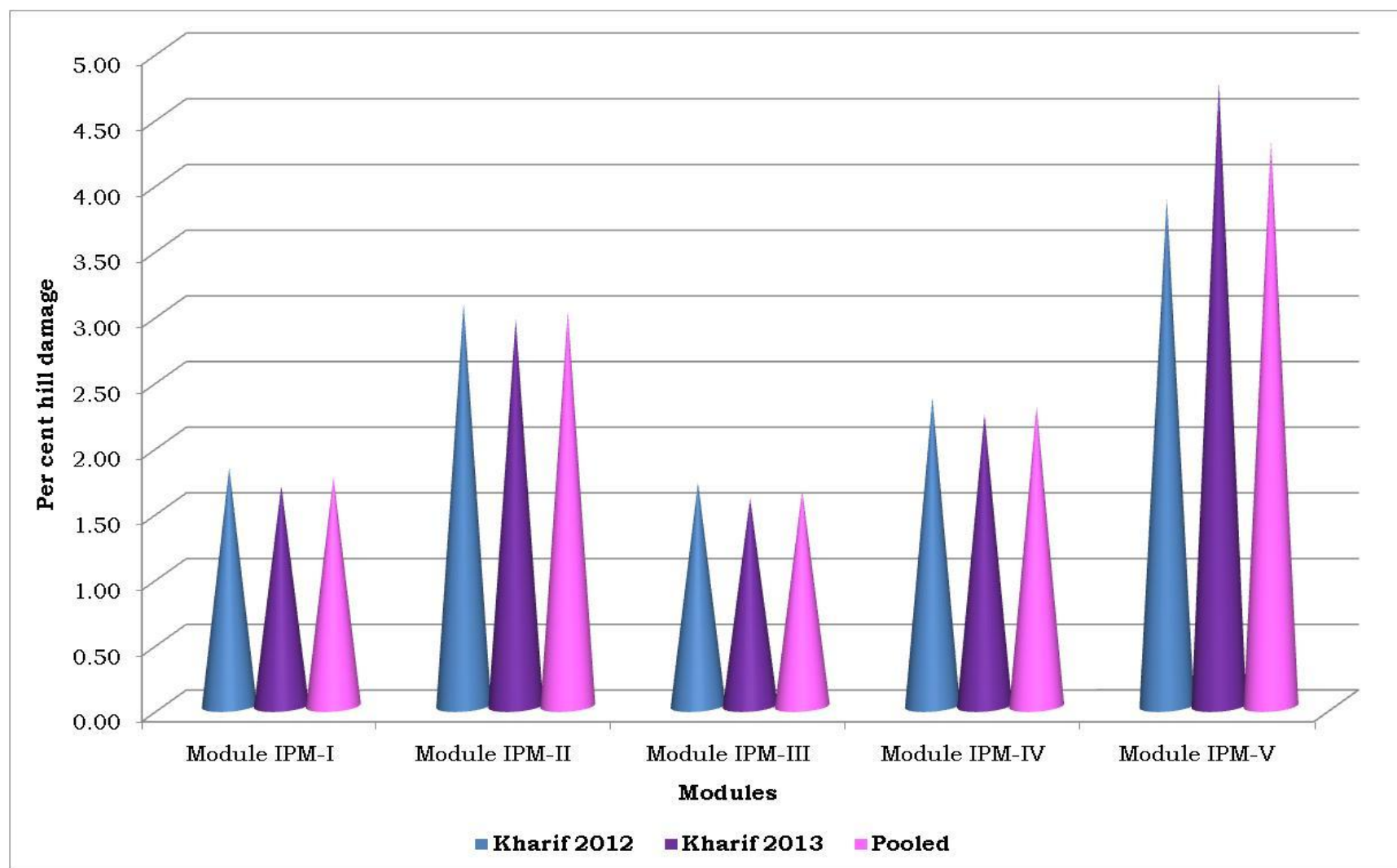


Fig. 39: Evaluation of modules against rice green leafhopper at 70 days after transplanting



Plate No. 26: Spraying on experimental plot

c. Pooled:**i. 50 DAT:**

The pooled data at 50 DAT showed significant result of different modules followed for management of green leafhoppers (Table 48 and Fig. 37). The minimum hill damage (4.20%) was recorded in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) (4.66%), but they were found comparable with each other. The next effective module was Module IPM-IV (spot application) with 4.78% hill damage, but it was found with previous Module IPM-I. Module IPM-II (non-chemical based module) recorded 5.63% hill damage and showed significantly lower damage than Module IPM-V (farmer's practices) (6.84%). The interaction effect between modules and year was non-significant.

ii. 60 DAT:

The pooled data of per cent hill damage due to green leafhoppers at 60 DAT revealed significant results among different modules and showed analogous trend as found at 50 DAT (Table 48 and Fig. 38). Module IPM-III (chemical + non-chemical based module) with 2.82% infestation found superior among other modules, but showed at par results with Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 2.97 and 3.16% hill damage, respectively. Module IPM-II (non-chemical based module) recorded higher hill damage (4.02%) as compare to other modules, but found significantly effective over Module IPM-V (farmer's practices) (4.97%). The interaction effect between modules and year was non-significant.

iii. 70 DAT:

The similar trend on performance of modules against green leafhoppers was recorded at 70 DAT in pooled results and showed significant findings (Table 48 and Fig. 39). The lowest hill damage (1.64%) was found in Module IPM-III (chemical + non-chemical based module) and showed comparable results with Module IPM-I (chemical

based module) (1.74%). The significantly effective performance was also found in Module IPM-IV (spot application) with 2.28% hill damage, followed by Module IPM-II (non-chemical based module), which recorded 3.00% hill infestation. The highest hill damage of 4.30% was found in Module IPM-V (farmer's practices).

The hill damage interaction between modules and year was found non-significant, which revealed consistent performance of module treatments during the period of both years. However, the hill damage in all IPM Module showed decreasing trend in successive period. The performance of modules against green leafhopper is not discussed due to want of literature.

4.4.3 Brown plant hopper (*N. lugens*):

The effectiveness of different modules against brown plant hopper at 50, 60 and 70 DAT is presented in Table 49 and depicted graphically in Fig. 40 to 42.

a. First Year (*Kharif* 2012):

i. 50 DAT:

During *Kharif* 2012 at 50 DAT, the result of different modules against brown plant hopper was found significant (Table 49 and Fig. 40). The minimum hill damage (4.64%) was recorded in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) and Module IPM-IV (spot application) with 5.16 and 5.21% hill damage but these three modules showed comparable results with each other. The other Module IPM-II (non-chemical based module) recorded 6.57% hill damage and showed significantly lower damage than Module IPM-V (farmer's practices) (7.80%).

ii. 60 DAT:

The data on per cent hill damage due to brown plant hoppers found at 60 DAT revealed significant findings (Table 49 and Fig. 41). Module IPM-III (chemical + non-chemical based module) with 2.70% hill infestation found superior among other modules, but similar results also

found in Module IPM-I (chemical based module) (3.07%). The next best module was Module IPM-IV (spot application), which recorded 3.77% hill damage, followed by Module IPM-II (non-chemical based module) recorded higher hill damage of 4.54% as compare to other modules. These modules found significantly effective over Module IPM-V (farmer's practices) (6.16%).

iii. 70 DAT:

The similar type of trend on performance of modules against brown plant hoppers was recorded at 70 DAT and also showed significant results (Table 49 and Fig. 42). The lowest hill damage (1.78%) was found in Module IPM-III (chemical + non-chemical based module), but found at par with Module IPM-I (chemical based module) (1.92%). The next effective module was Module IPM-IV (spot application) with 2.45% hill damage, followed by Module IPM-II (non-chemical based module) which recorded 3.19% hill infestation. The highest hill damage of 5.34% was observed in Module IPM-V (farmer's practices).

b. Second Year (*Kharif* 2013):

i. 50 DAT:

During *Kharif* 2013 at 50 DAT, the results of brown plant hoppers showed significant difference among different modules (Table 49 and Fig. 40). The minimum hill damage (4.53%) was recorded in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) and Module IPM-IV (spot application) with 4.98 and 5.32% hill damage and the results of all these three modules found comparable with each other. Module IPM-II (non-chemical based module) recorded 6.48% hill damage due to brown plant hopper and showed significantly lower damage than Module IPM-V (farmer's practices) (7.71%).

Table 49: Evaluation of modules against rice brown plant hopper during *Kharif* 2012 and *Kharif* 2013

Sr. No.	Name of module	% hill damage at 50 DAT			% hill damage at 60 DAT			% hill damage at 70 DAT		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
1.	Module IPM-I (Chemical based module)	13.09 (5.16)	12.84 (4.98)	12.97 (5.07)	10.05 (3.07)	10.20 (3.16)	10.12 (3.11)	7.95 (1.92)	8.05 (1.97)	8.00 (1.94)
2.	Module IPM -II (Non-chemical based module)	14.81 (6.57)	14.71 (6.48)	14.76 (6.53)	12.28 (4.54)	12.45 (4.67)	12.37 (4.61)	10.24 (3.19)	10.48 (3.33)	10.36 (3.26)
3.	Module IPM -III (Chemical + Non-chemical based module)	12.40 (4.64)	12.25 (4.53)	12.32 (4.59)	9.44 (2.70)	9.54 (2.76)	9.49 (2.73)	7.63 (1.78)	7.65 (1.79)	7.64 (1.79)
4.	Module IPM -IV (Spot application)	13.20 (5.21)	13.33 (5.32)	13.26 (5.27)	11.19 (3.77)	11.29 (3.84)	11.24 (3.81)	8.97 (2.45)	9.27 (2.61)	9.12 (2.53)
5.	Module IPM -V (Farmer's practices)	16.19 (7.80)	16.10 (7.71)	16.14 (7.75)	14.34 (6.16)	14.21 (6.05)	14.28 (6.11)	13.36 (5.34)	12.12 (4.44)	12.74 (4.89)
	S. E. (m) $\pm$ (T)	0.39	0.41	0.27	0.36	0.34	0.24	0.33	0.39	0.26
	C. D. at 5% (T)	1.15	1.21	0.77	1.05	1.01	0.67	0.96	1.14	0.74
	S. E. (m) $\pm$ (YxT)	--	--	0.40	--	--	0.35	--	--	0.36
	C. D. at 5% (YxT)	--	--	NS	--	--	NS	--	--	NS
	C. V.	6.87	7.25	7.05	7.62	7.24	7.43	8.29	9.95	9.15

* Values in outside the parentheses are arc sine transformed values and inside are original values.

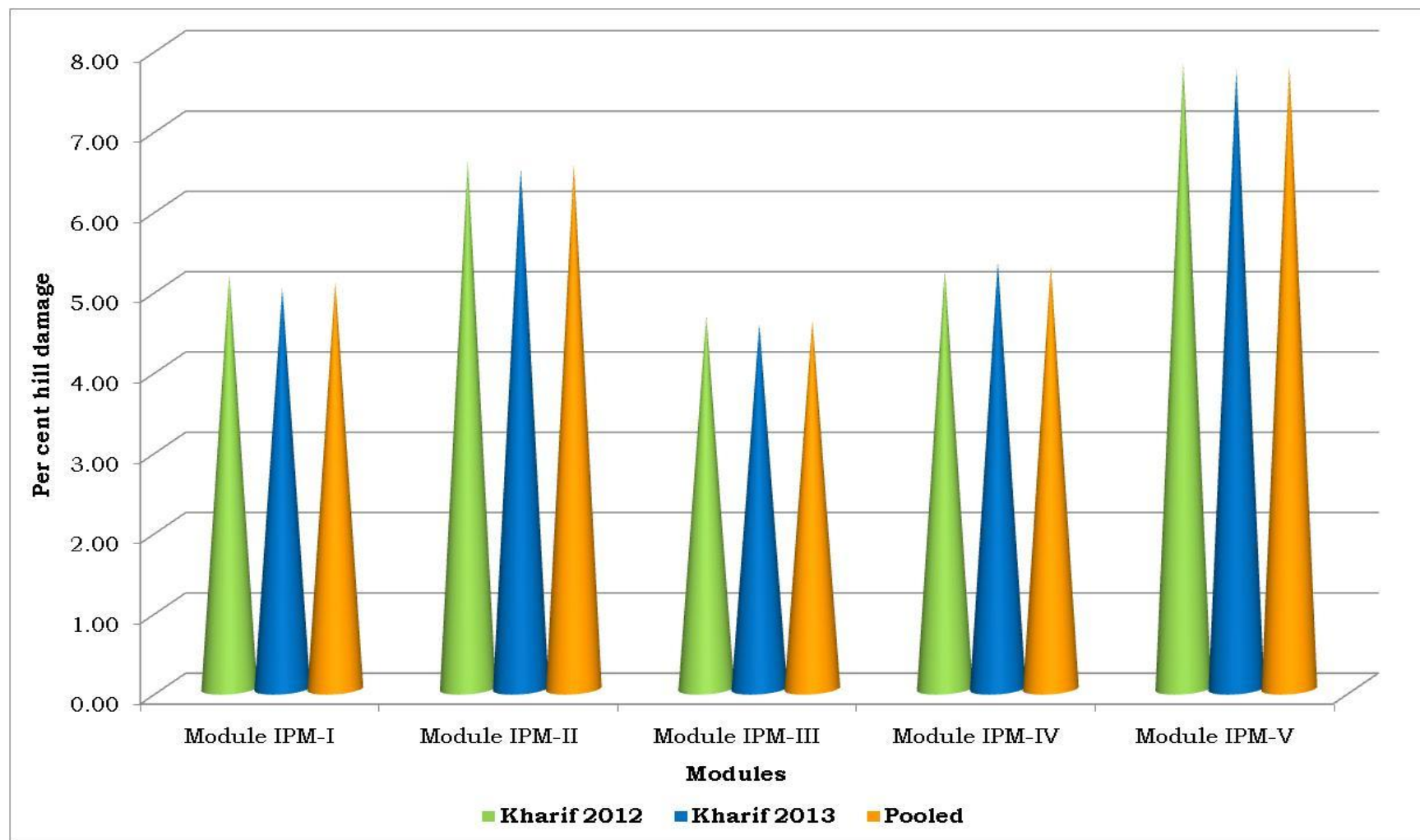


Fig. 40: Evaluation of modules against rice brown plant hopper at 50 days after transplanting

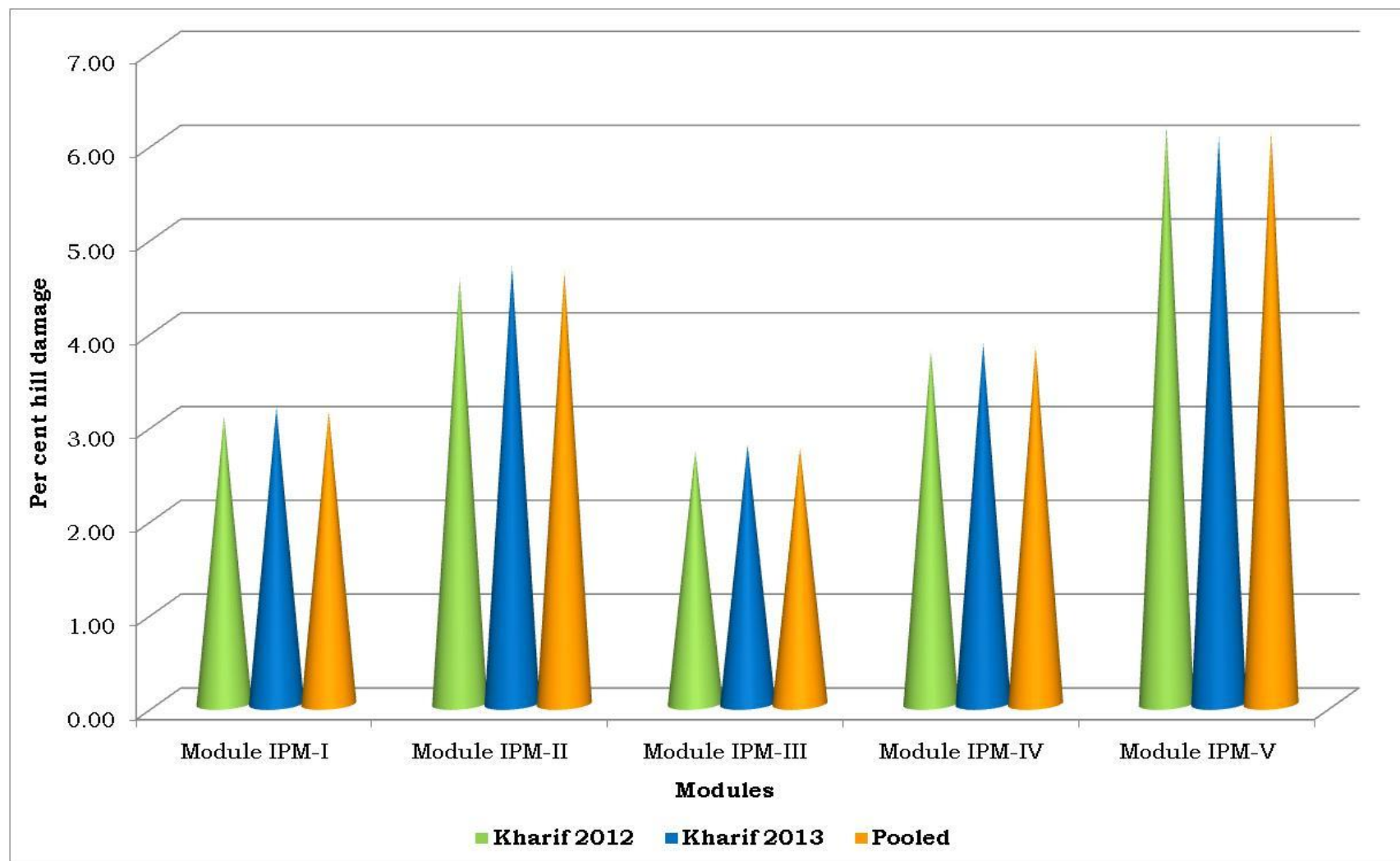


Fig. 41: Evaluation of modules against rice brown plant hopper at 60 days after transplanting

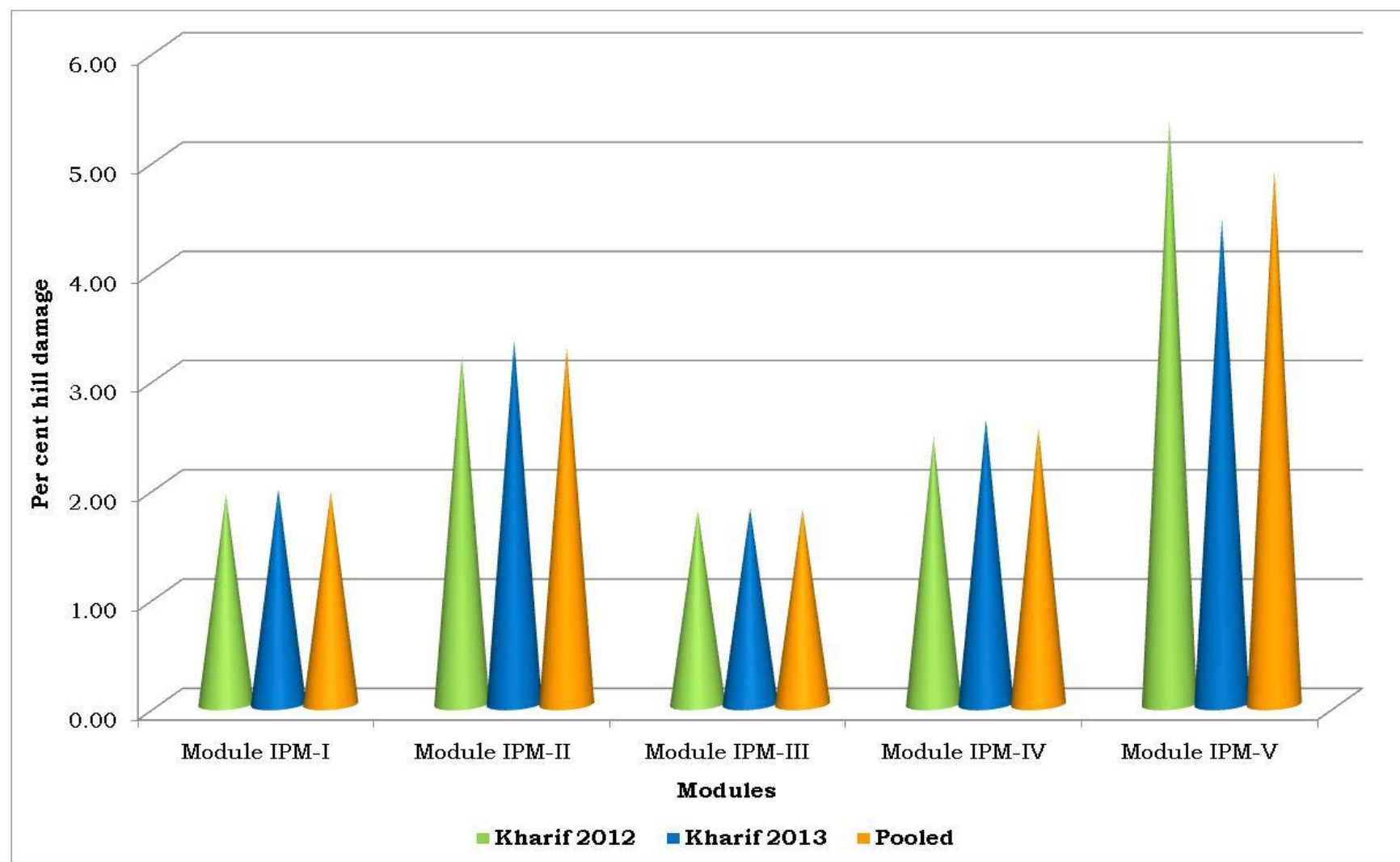


Fig. 42: Evaluation of modules against rice brown plant hopper at 70 days after transplanting

ii. 60 DAT:

The results on per cent hill damage due to brown plant hoppers at 60 DAT revealed significant findings (Table 49 and Fig. 41). Module IPM-III (chemical + non-chemical based module) with 2.76% infestation found superior among other modules, but recorded parallel results with Module IPM-I (chemical based module), which showed 3.16% hill damage. The next effective module was Module IPM-IV (spot application) (3.84%), followed by Module IPM-II (non-chemical based module) recorded 4.76% hill damage due to brown plant hopper. The highest hill damage of 6.05% was found in Module IPM-V (farmer's practices).

iii. 70 DAT:

The similar trend of modules performance against brown plant hopper was observed at 70 DAT and also showed significant results (Table 49 and Fig. 42). The lowest hill damage (1.79%) was found in Module IPM-III (chemical + non-chemical based module), but showed comparable findings with Module IPM-I (chemical based module) (1.97%). The other significantly effective module was Module IPM-IV (spot application) with 2.61% hill damage, followed by Module IPM-II (non-chemical based module), which recorded 3.33% hill infestation due to brown plant hopper. The highest hill damage of 4.44% was found in Module IPM-V (farmer's practices).

a. Pooled:**i. 50 DAT:**

The pooled data at 50 DAT showed significant results of different modules followed for management of brown plant hoppers (Table 49 and Fig. 40). The minimum hill damage (4.59%) was observed in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) (5.07%) and showed at par results. The next effective module was Module IPM-IV (spot application) with 5.27% hill damage, but showed comparable results with Module IPM-I. The other Module IPM-II (non-chemical based module) recorded 6.53% hill damage

and showed significantly lower damage than Module IPM-V (farmer's practices) (7.75%).

ii. 60 DAT:

The pooled data on per cent hill damage due to brown plant hoppers found at 60 DAT revealed significant findings among different modules (Table 49 and Fig. 41). Module IPM-III (chemical + non-chemical based module) with 2.73% hill infestation found superior among other modules, but similar results also depicted in Module IPM-I (chemical based module) (3.11%). The next best module was Module IPM-IV (spot application), which recorded 3.81% hill damage, followed by Module IPM-II (non-chemical based module) recorded higher hill damage of 4.61% as compare to other modules. These modules found significantly effective over Module IPM-V (farmer's practices) (6.11%).

iii. 70 DAT:

The similar type of trend on performance of modules against brown plant hoppers was recorded at 70 DAT in pooled data and also showed significant results (Table 49 and Fig42). The lowest hill damage (1.79%) was found in Module IPM-III (chemical + non-chemical based module), but found at par with Module IPM-I (chemical based module) (1.94%). The next effective module was Module IPM-IV (spot application) with 2.53% hill damage, followed by Module IPM-II (non-chemical based module) which recorded 3.26% hill infestation. The highest hill damage of 4.89% was found in Module IPM-V (farmer's practices).

The interaction effect between modules and year was found non-significant, which revealed consistent performance of module treatments during the period of both years. However, the hill damage in all IPM Module showed decreasing trend in successive period.

4.4.4 Leaf Folder (*C. medinalis*):

The results on leaf damage caused due to leaf folder at 50, 60 and 70 DAT under different modules is presented in Table 50 and depicted Fig. 43 to 45.

a. First Year (*Kharif* 2012):**i. 50 DAT:**

During *Kharif* 2012 at 50 DAT, the results of different modules against leaf folder were significant (Table 50 and Fig. 43). The significantly minimum leaf damage (2.05%) was recorded in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) with 2.59% leaf damage. The next effective module was Module IPM-II (non-chemical based module) recorded 3.20% leaf damage due to leaf folder, which also showed comparable results with Module IPM-IV (spot application) with 3.51% leaf damage. The maximum leaf damage was found in Module IPM-V (farmer's practices) (5.19%).

ii. 60 DAT:

At 60 DAT, the results of different modules against leaf folder revealed significant findings (Table 50 and Fig. 44). Module IPM-III (chemical + non-chemical based module) with 1.72% leaf infestation showed superiority over other modules, but similar results were also found in Module IPM-I (chemical based module) (2.17%). The next best module was Module IPM-IV (spot application), which recorded 2.23% leaf damage, but showed comparable results with Module IPM-I (chemical based module). Module IPM-II (non-chemical based module) recorded 2.85% leaf damage due to leaf folder and showed significantly lower damage than Module IPM-V (farmer's practices) (4.62%).

iii. 70 DAT:

The similar trend on performance of modules against leaf folder was recorded at 70 DAT with significant results (Table 50 and Fig. 45). The Significantly lowest hill damage (0.91%) was found in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) (1.35%). The next effective module was Module IPM-IV (spot application) with 1.52% leaf damage due to leaf folder, but showed similar results with Module IPM-I (chemical based module).

Module IPM-II (non-chemical based module) showed 2.03% leaf damage, but recorded significantly lower damage than Module IPM-V (farmer's practices) with 3.57% leaf damage.

a. Second Year (*Kharif* 2013):

i. 50 DAT:

At 50 DAT, the data of leaf folder showed significant differences among different modules (Table 50 and Fig. 43). Significantly minimum leaf damage (1.97%) was recorded in Module IPM-III (chemical + non-chemical based module) among all modules, followed by Module IPM-I (chemical based module) and Module IPM-II (non-chemical based module) with 2.51 and 3.12% leaf damage. The next best module was Module IPM-IV (spot application) (3.41%), but showed comparable results with previous Module IPM-II. The maximum leaf damage due to leaf folder was found in Module IPM-V (farmer's practices) (5.06%).

ii. 60 DAT:

During *Kharif* 2013 at 60 DAT, the data of different modules against leaf folder revealed significant results (Table 50 and Fig. 44). Module IPM-III (chemical + non-chemical based module) with 1.66% leaf infestation showed superiority over other modules and found effective in reducing the leaf folder infestation. The next best module was Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 2.18 and 2.35% leaf damage but depicted comparable results with each other. Module IPM-II (non-chemical based module) recorded 2.96% leaf damage due to leaf folder and showed significantly lower damage than Module IPM-V (farmer's practices) (5.00%).

Table 50: Evaluation of modules against rice leaf folder during *Kharif* 2012 and *Kharif* 2013

Sr. No.	Name of module	% leaf damage at 50 DAT			% leaf damage at 60 DAT			% leaf damage at 70 DAT		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
1.	Module IPM-I (Chemical based module)	9.23 (2.59)	9.08 (2.51)	9.15 (2.55)	8.39 (2.17)	8.42 (2.18)	8.41 (2.17)	6.60 (1.35)	6.89 (1.47)	6.74 (1.41)
2.	Module IPM -II (Non-chemical based module)	10.30 (3.20)	10.17 (3.12)	10.24 (3.16)	9.71 (2.85)	9.90 (2.96)	9.81 (2.90)	8.17 (2.03)	8.30 (2.10)	8.24 (2.06)
3.	Module IPM -III (Chemical + Non-chemical based module)	8.18 (2.05)	8.01 (1.97)	8.10 (2.01)	7.44 (1.72)	7.30 (1.66)	7.37 (1.69)	5.45 (0.91)	5.63 (0.97)	5.54 (0.94)
4.	Module IPM -IV (Spot application)	10.79 (3.51)	10.62 (3.41)	10.70 (3.46)	8.57 (2.23)	8.80 (2.35)	8.69 (2.29)	7.05 (1.52)	7.30 (1.63)	7.18 (1.57)
5.	Module IPM -V (Farmer's practices)	13.13 (5.19)	12.97 (5.06)	13.05 (5.12)	12.41 (4.62)	12.91 (5.00)	12.66 (4.81)	10.86 (3.57)	11.53 (4.01)	11.20 (3.79)
S. E. (m) _± (T)		0.34	0.35	0.23	0.38	0.36	0.25	0.34	0.32	0.23
C. D. at 5% (T)		1.01	1.02	0.66	1.11	1.07	0.72	1.02	0.96	0.65
S. E. (m) _± (YxT)		--	--	0.34	--	--	0.37	--	--	0.33
C. D. at 5% (YxT)		--	--	NS	--	--	NS	--	--	NS
C. V.		8.10	8.35	8.22	9.91	9.40	9.60	11.06	10.02	10.53

* Values in outside the parentheses are arc sine transformed values and inside are original values.

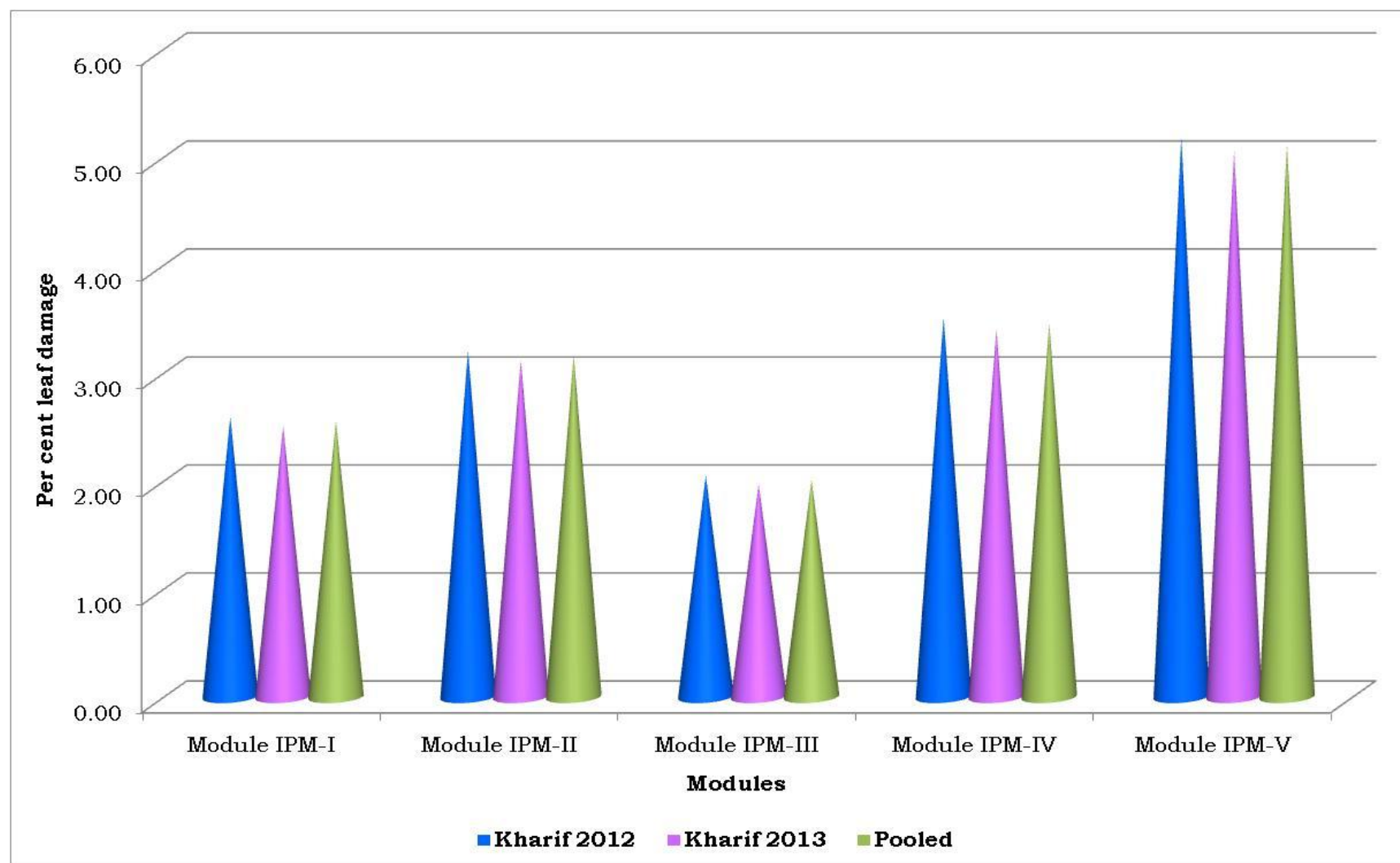


Fig. 43: Evaluation of modules against rice leaf folder at 50 days after transplanting

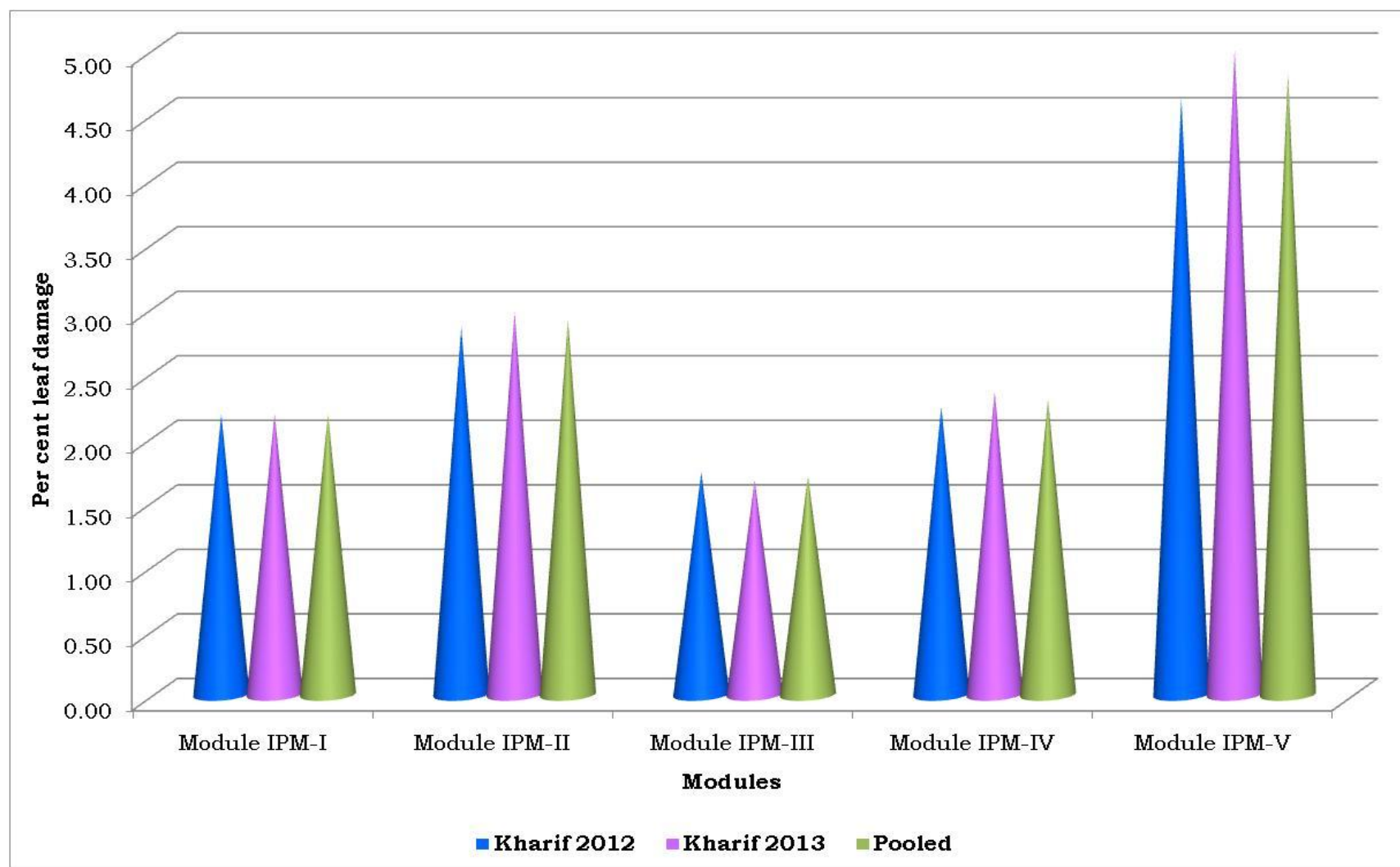


Fig. 44: Evaluation of modules against rice leaf folder at 60 days after transplanting

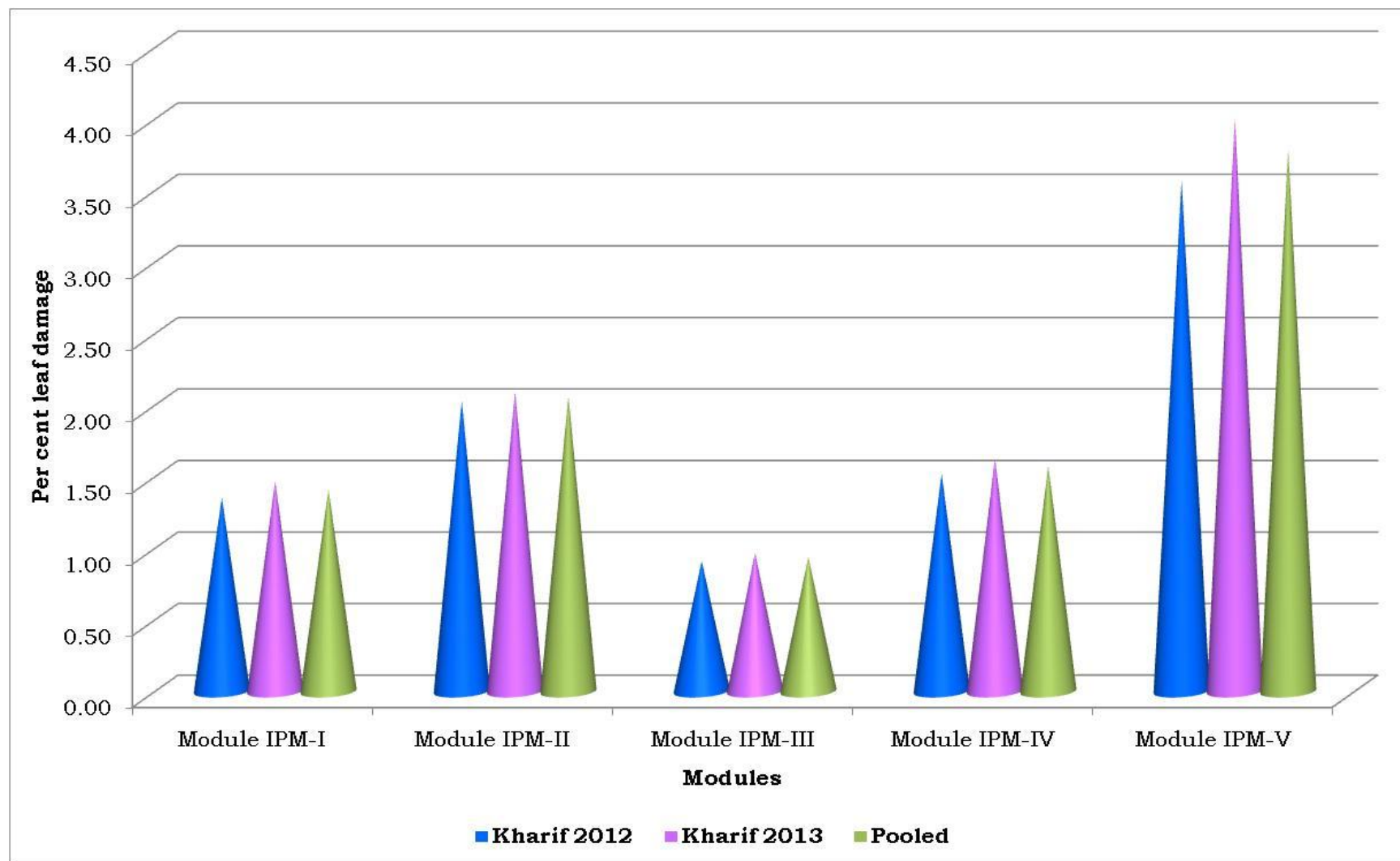


Fig. 45: Evaluation of modules against rice leaf folder at 70 days after transplanting

iii. 70 DAT:

Similar trend on performance of modules against leaf folder was recorded at 70 DAT with significant results (Table 50 and Fig. 45). Significantly lowest hill damage (0.97%) was found in Module IPM-III (chemical + non-chemical based module). The next best module was Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 1.47 and 1.63% leaf damage due to leaf folder, respectively, but showed similar results with each other. Module IPM-II (non-chemical based module) recorded 2.10% leaf damage and recorded significantly lower damage than Module IPM-V (farmer's practices) (4.01%).

a. Pooled:**i. 50 DAT:**

In pooled data recorded at 50 DAT, the results of different modules used against leaf folder were significant (Table 50 and Fig. 43). significantly minimum leaf damage (2.01%) was recorded in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) with 2.55% leaf damage. The next effective module was Module IPM-II (non-chemical based module) recorded 3.16% leaf damage, which also showed comparable results with next Module IPM-IV (spot application) (3.46%). The maximum leaf damage was found in Module IPM-V (farmer's practices) (5.12%).

ii. 60 DAT:

At 60 DAT, the pooled result leaf folder revealed significant findings among different modules (Table 50 and Fig. 44). Module IPM-III (chemical + non-chemical based module) with 1.69% leaf infestation showed significantly superiority over other modules, followed by Module IPM-I (chemical based module) (2.17%). The next best module was Module IPM-IV (spot application), which recorded 2.29% leaf damage, but showed comparable results with Module IPM-I. Module IPM-II (non-chemical based module) recorded 2.90% leaf damage due to leaf folder

and showed significantly lower damage than Module IPM-V (farmer's practices) (4.81%).

iii. 70 DAT:

In pooled data, the similar trend on performance of modules against leaf folder was recorded at 70 DAT with significant results (Table 50 and Fig. 45). Significantly lowest hill damage (0.94%) was found in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module) (1.41%). The next effective module was Module IPM-IV (spot application) with 1.57% leaf damage due to leaf folder, but showed similar results with Module IPM-I. Module IPM-II (non-chemical based module) recorded 2.06% leaf damage, but recorded significantly lower damage over Module IPM-V (farmer's practices) (3.79%).

The interaction effect between modules and year was found non-significant, which revealed consistent performance of module treatments during the period of both the years. However, the leaf damage in all IPM Module showed decreasing trend in successive period.

In previous finding on IPM, the results of Mohapatra (2008) showed that Integrated pest management (IPM) crop suffered with less incidence of leaf folder in basmati rice (Pusa Basmati-1) in contrast with farmer's practice (FP) and Chemical based pest management (CBP). Similarly, Patel *et al.* (2009) carried out study at Nawagam (Gujarat) and the results revealed that IPM exhibited a lower incidence of leaf folder, *C. medinalis* on rice than farmer's practices. In another investigation, Karthikeyan *et al.* (2010) conducted field experiments with 3 rice IPM modules and the results showed that the IPM III module comprised alternate spraying with neem-based formulation and newer safer insecticide coupled with release of egg parasitoids against leaf folder resulted in significant reduction of leaf folder over farmer's practices. Also, Elakkiya *et al.* (2011) showed that per cent leaf damage was less in eco-friendly IPM module in two the seasons.

While, Mahal *et al.* (2011) revealed that the incidence of leaf folder was lower in IPM model-I (Traps + chemical control) and IPM model-II (Traps + tricho-cards + chemical control) than farmer's practices. All these above mentioned research findings support the present results of superiority of chemical and non-chemical based modules.

4.4.5 Blue beetle (*L. pygmaea*):

The data on leaf damage caused by blue beetle under different modules at 30, 50 and 60 DAT is presented in Table 51 and depicted Fig. 46 to 48.

a. First Year (*Kharif* 2012):

i. 30 DAT:

During *Kharif* 2012 at 30 DAT, the result of different modules used for blue beetle was found significant (Table 51 and Fig. 46) and the minimum leaf damage (2.61%) was recorded in Module IPM-III (chemical + non-chemical based module). The next best module was Module IPM-I (chemical based module) and Module IPM-IV (spot application) with 3.23 and 3.35% leaf damage but depicted comparable results with each other. Module IPM-II (non-chemical based module) recorded 3.96% leaf damage and showed significantly lower damage than Module IPM-V (farmer's practices) (5.08%).

ii. 50 DAT:

The similar type of performance trend was found in different modules used against blue beetle at 50 DAT with significant results (Table 51 and Fig. 47). The significantly lowest hill damage (1.59%) was found in Module IPM-III (chemical + non-chemical based module). The next effective module was Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 2.09 and 2.43% leaf damage but showed similar results. Module IPM-II (non-chemical based module) recorded 3.00% leaf damage due to blue beetle and showed significant superiority over Module IPM-V (farmer's practices) (4.46%).

iii. 60 DAT:

At 60 DAT, all the IPM modules used against blue beetle showed significant results over farmer's practices (Module IPM-IV) (Table 51 and Fig. 48). Significantly lowest hill damage (0.89%) was found in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module), Module IPM-IV (spot application) and Module IPM-II (non-chemical based module) recorded 1.16, 1.49 and 2.17% leaf damage due to blue beetle, respectively. The maximum leaf damage was found in Module IPM-V (farmer's practices) (3.99%).

a. Second Year (*Kharif* 2013):

i. 30 DAT:

At 30 DAT, the data of different modules against blue beetle was found significant (Table 51 and Fig. 46). Significantly minimum leaf damage (2.50%) was recorded in Module IPM-III (chemical + non-chemical based module). The next best module was Module IPM-I (chemical based module) and Module IPM-IV (spot application) with 3.14 and 3.30% leaf damage but showed comparable results with each other. Module IPM-II (non-chemical based module) recorded 3.93% leaf damage due to blue beetle and found significantly superior over Module IPM-V (farmer's practices) (4.68%).

ii. 50 DAT:

During *Kharif* 2013 at 50 DAT, the data of blue beetle showed significant results among different modules (Table 51 and Fig. 47). Module IPM-III (chemical + non-chemical based module) with 1.46% leaf infestation showing superiority over other modules. The next best module was Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 2.01 and 2.32% leaf damage but showed comparable results with each other. Module IPM-II (non-chemical based module) recorded 2.93% leaf damage due to blue beetle and showed significantly lower damage than Module IPM-V (farmer's practices) (4.05%).

Table 51: Evaluation of modules against rice blue beetle during *Kharif* 2012 and *Kharif* 2013

Sr. No.	Name of module	% leaf damage at 30 DAT			% leaf damage at 50 DAT			% leaf damage at 60 DAT		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled	<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
1.	Module IPM-I (Chemical based module)	10.30 (3.23)	10.16 (3.14)	10.23 (3.19)	8.23 (2.09)	8.06 (2.01)	8.15 (2.05)	6.15 (1.16)	6.28 (1.22)	6.21 (1.19)
2.	Module IPM -II (Non-chemical based module)	11.48 (3.96)	11.42 (3.93)	11.45 (3.95)	9.96 (3.00)	9.84 (2.93)	9.90 (2.96)	8.47 (2.17)	8.39 (2.14)	8.43 (2.15)
3.	Module IPM -III (Chemical + Non-chemical based module)	9.26 (2.61)	9.06 (2.50)	9.16 (2.55)	7.21 (1.59)	6.87 (6.87)	7.04 (1.52)	5.33 (0.89)	5.06 (0.81)	5.20 (0.85)
4.	Module IPM -IV (Spot application)	10.54 (3.35)	10.45 (3.30)	10.50 (3.33)	8.95 (2.43)	8.72 (2.32)	8.84 (2.38)	7.00 (1.49)	6.93 (1.46)	6.97 (1.48)
5.	Module IPM -V (Farmer's practices)	13.01 (5.08)	12.48 (4.68)	12.74 (4.88)	12.17 (4.46)	11.61 (4.05)	11.89 (4.26)	11.51 (3.99)	11.53 (4.01)	11.52 (4.00)
S. E. (m) $\pm$ (T)		0.31	0.32	0.21	0.33	0.34	0.23	0.26	0.33	0.20
C. D. at 5% (T)		0.90	0.93	0.60	0.96	1.00	0.64	0.77	0.98	0.58
S. E. (m) $\pm$ (YxT)		--	--	0.31	--	--	0.33	--	--	0.30
C. D. at 5% (YxT)		--	--	NS	--	--	NS	--	--	NS
C. V.		6.88	7.24	7.06	8.57	9.24	8.89	8.32	10.67	9.56

* Values in outside the parentheses are arc sine transformed values and inside are original values.

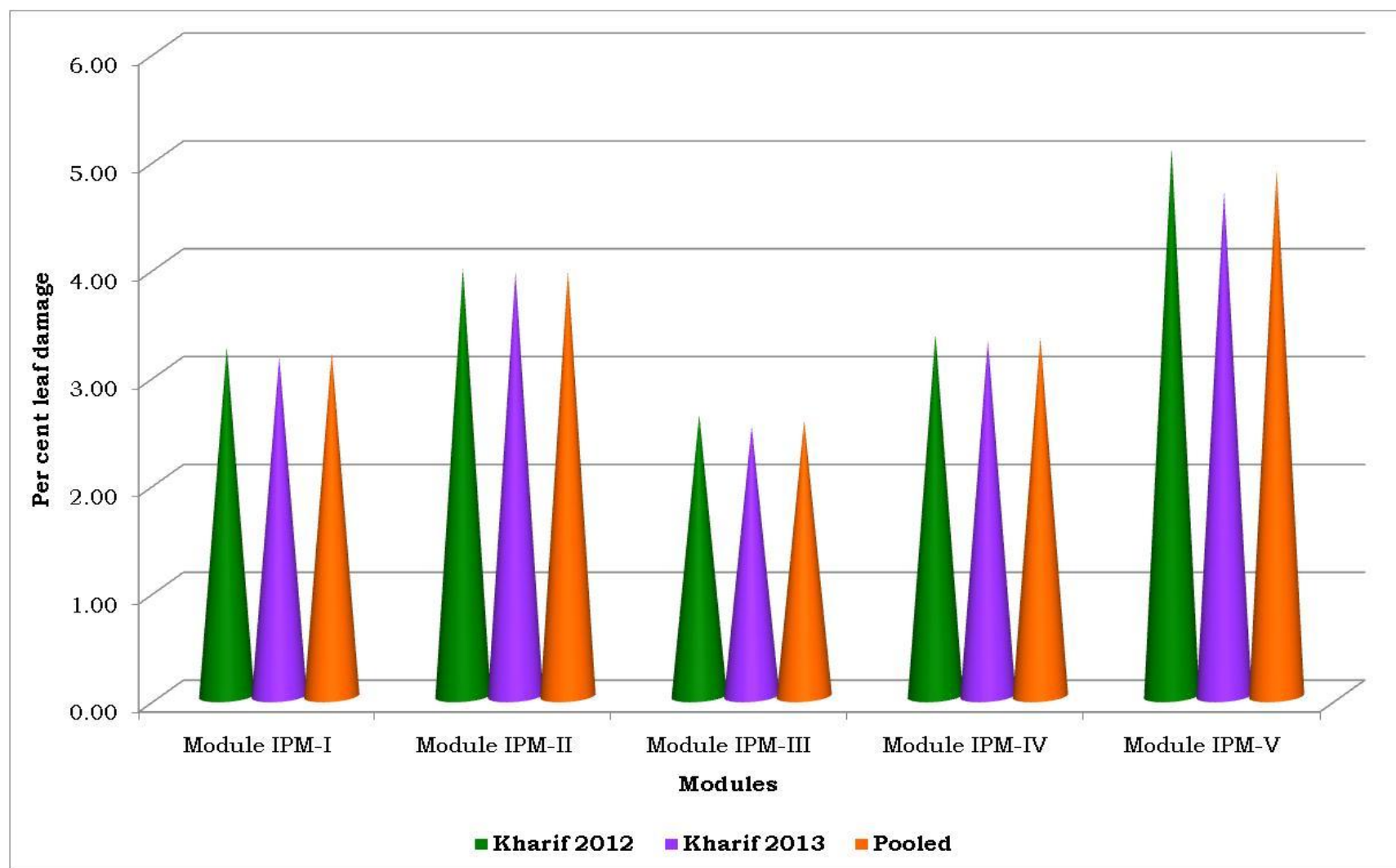


Fig. 46: Evaluation of modules against rice blue beetle at 30 days after transplanting

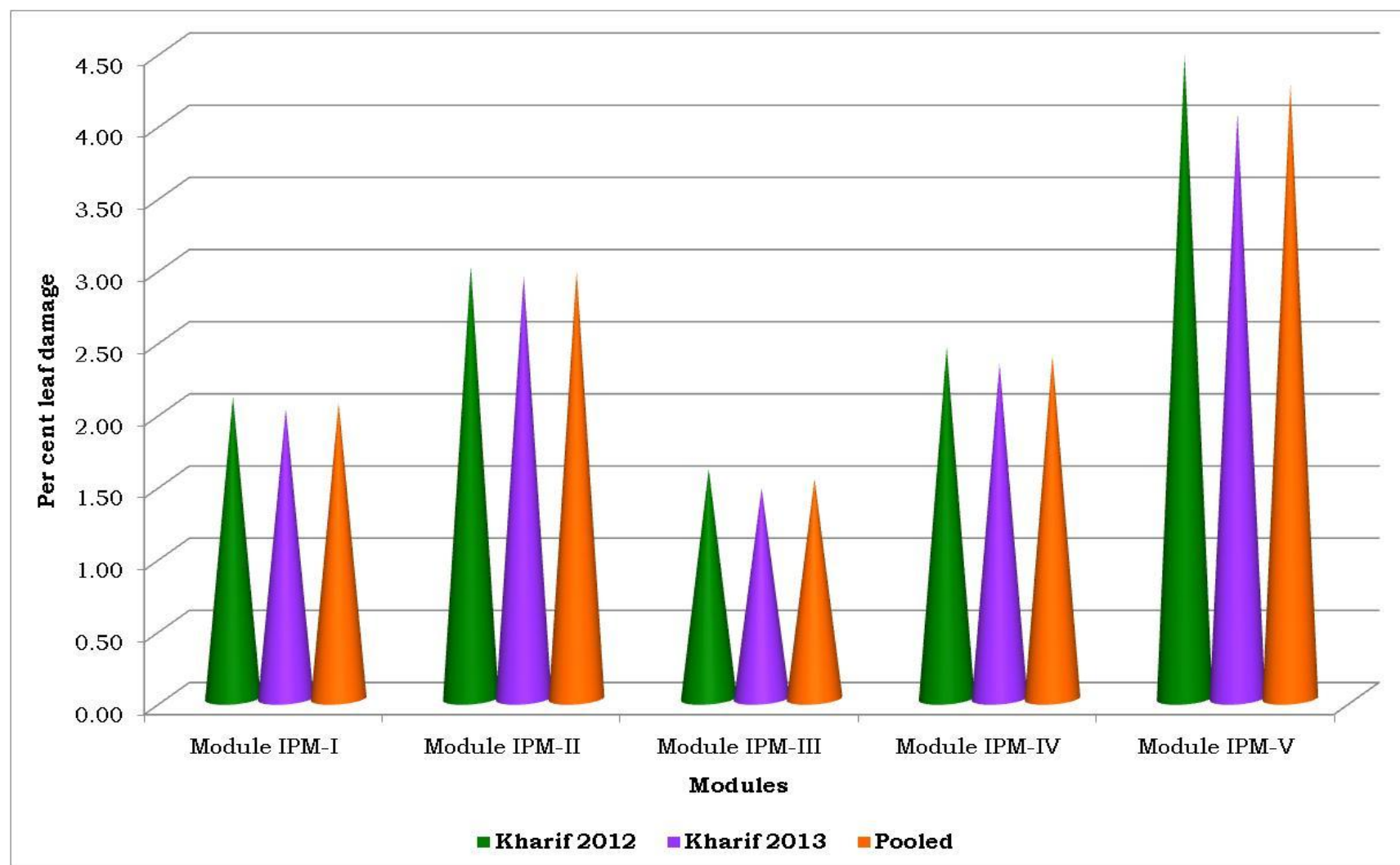


Fig. 47: Evaluation of modules against rice blue beetle at 50 days after transplanting

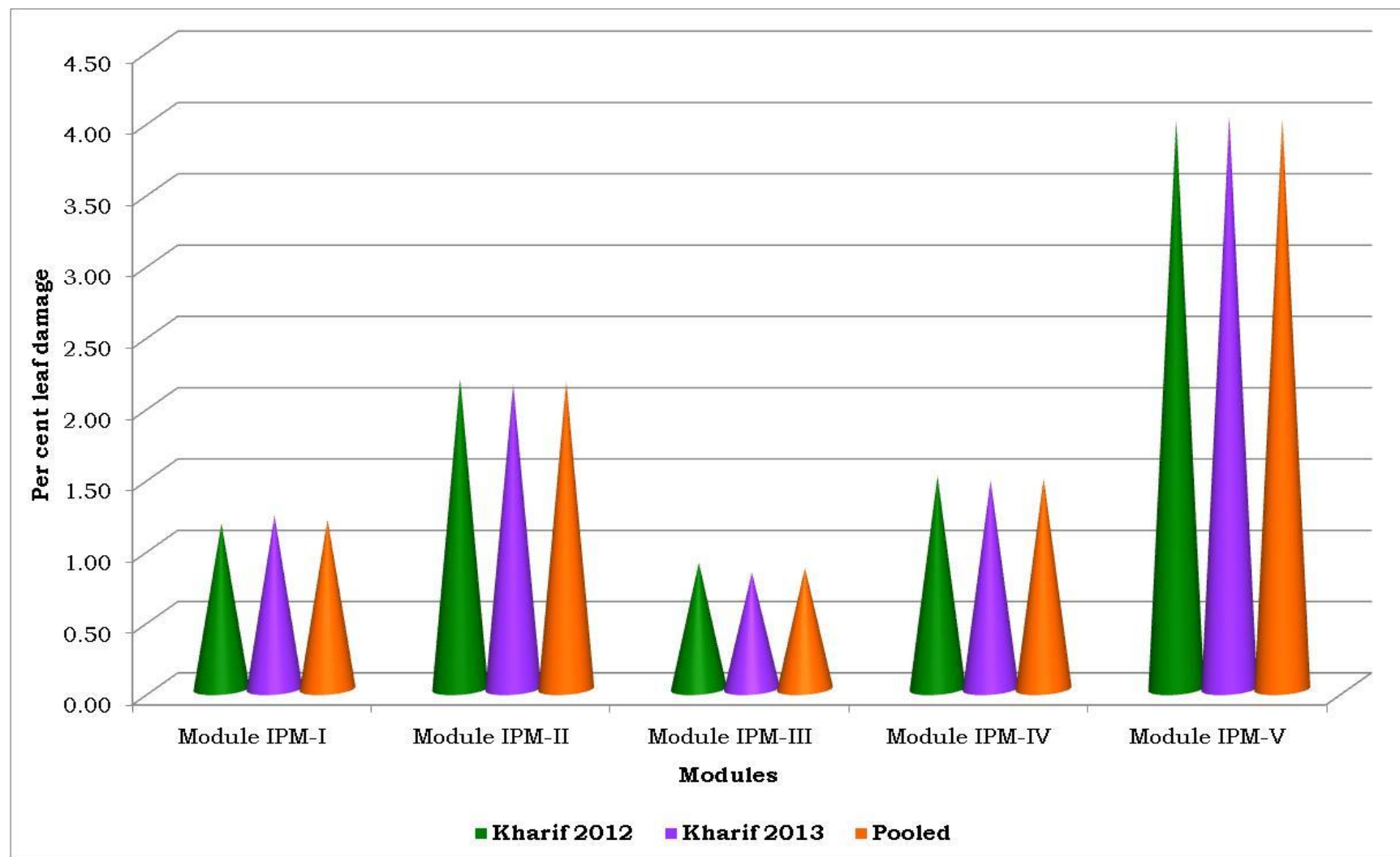


Fig. 48: Evaluation of modules against rice blue beetle at 60 days after transplanting

iii. 60 DAT:

The similar performance trend of modules against blue beetle was recorded at 60 DAT with significant results (Table 51 and Fig. 48). Significantly lowest leaf damage (0.81%) was found in Module IPM-III (chemical + non-chemical based module). The next best module was Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 1.22 and 1.46% leaf damage but showed similar results with each other. Module IPM-II (non-chemical based module) recorded 2.14% leaf damage and showed significantly lower damage over Module IPM-V (farmer's practices) (4.01%).

a. Pooled:**i. 30 DAT:**

In pooled results of blue beetle at 30 DAT, the different modules showed significant performance (Table 51 and Fig. 46). The significantly minimum leaf damage (2.55%) was recorded in Module IPM-III (chemical + non-chemical based module). The next best modules were Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 3.19 and 3.33% leaf damage but showed comparable results with each other. Module IPM-II (non-chemical based module) recorded 3.95% leaf damage due to blue beetle and recorded significantly lower damage than Module IPM-V (farmer's practices) (4.88%).

ii. 50 DAT:

The pooled data of blue beetle at 50 DAT revealed significant result among different modules (Table 51 and Fig. 47). Module IPM-III (chemical + non-chemical based module) with 1.52% leaf damage recorded superiority over other modules. The next effective modules were Module IPM-I (chemical based module), Module IPM-IV (spot application) and Module IPM-II (non-chemical based module), which recorded 2.05, 2.38 and 2.96% leaf damage, respectively. These modules found significantly superior over Module IPM-V (farmer's practices) (4.26%).

iii. 60 DAT:

The similar trend on performance of modules against blue beetle was recorded in pooled data at 60 DAT SHOWING significant results (Table 51 and Fig. 48). The significantly lowest leaf damage (0.85%) was found in Module IPM-III (chemical + non-chemical based module). The next best modules were Module IPM-I (chemical based module), Module IPM-IV (spot application) and Module IPM-II (non-chemical based module), which recorded 1.19, 1.48 and 2.15% leaf damage due to blue beetle, respectively. All the modules showed significantly lower damage than Module IPM-V (farmer's practices) (4.00%).

The interaction effect between modules and year was found non-significant, that showed consistent performance of module treatments during the period of both years. However, the leaf damage in all IPM Module showed decreasing trend in successive period.

The performance of modules against blue beetle is not discussed due to want of literature.

4.4.6 Yield and Economics:

a. First Year (*Kharif 2012*):

During *Kharif 2012*, the yield findings under different modules showed significant results (Table 52 and Fig. 49). Significantly highest yield (61.58 q/ha) was recorded in Module IPM-III (chemical + non-chemical based module). The next best modules were Module IPM-I (chemical based module) and Module IPM-IV (spot application), which recorded 56.33 and 55.25 q/ha yield but showed comparable results with each other. Module IPM-II (non-chemical based module) recorded 49.67 q/ha yield and recorded significantly lower damage than Module IPM-V (farmer's practices) (44.25 q/ha).

b. Second Year (*Kharif 2013*):

During *Kharif 2013*, the yield result of different modules revealed significant findings (Table 52 and Fig. 49). Module IPM-III (chemical + non-chemical based module) with 60.92 q/ha yield showed significant

superiority over other modules, followed by Module IPM-I (chemical based module) (55.92 q/ha). The next best module was Module IPM-IV (spot application), which recorded 54.25 q/ha yield, but showed comparable results with Module IPM-I. Module IPM-II (non-chemical based module) recorded 49.17 q/ha yield and showed significantly lower damage than Module IPM-V (farmer's practices) (43.17 q/ha).

Table 52: Yield performance in different modules of rice during *Kharif* 2012 and *Kharif* 2013

Sr. No.	Name of module	Yield (q/ha)		
		<i>Kharif</i> 2012	<i>Kharif</i> 2013	Pooled
1.	Module IPM-I (Chemical based module)	56.33	55.92	56.13
2.	Module IPM -II (Non-chemical based module)	49.67	49.17	49.42
3.	Module IPM -III (Chemical + Non-chemical based module)	61.58	60.92	61.25
4.	Module IPM -IV (Spot application)	55.25	54.25	54.75
5.	Module IPM -V (Farmer's practices)	44.25	43.17	43.71
S. E. (m) _± (T)		1.73	1.67	1.14
C. D. at 5% (T)		5.09	4.92	3.27
S. E. (m) _± (YxT)		--	--	1.70
C. D. at 5% (YxT)		--	--	NS
C. V.		7.92	7.76	7.84

c. Pooled:

In pooled data, the yield performance of different modules revealed significant results (Table 52 and Fig. 49). The highest yield (61.25 q/ha) was found in Module IPM-III (chemical + non-chemical based module). The next effective modules were Module IPM-I (chemical based module)

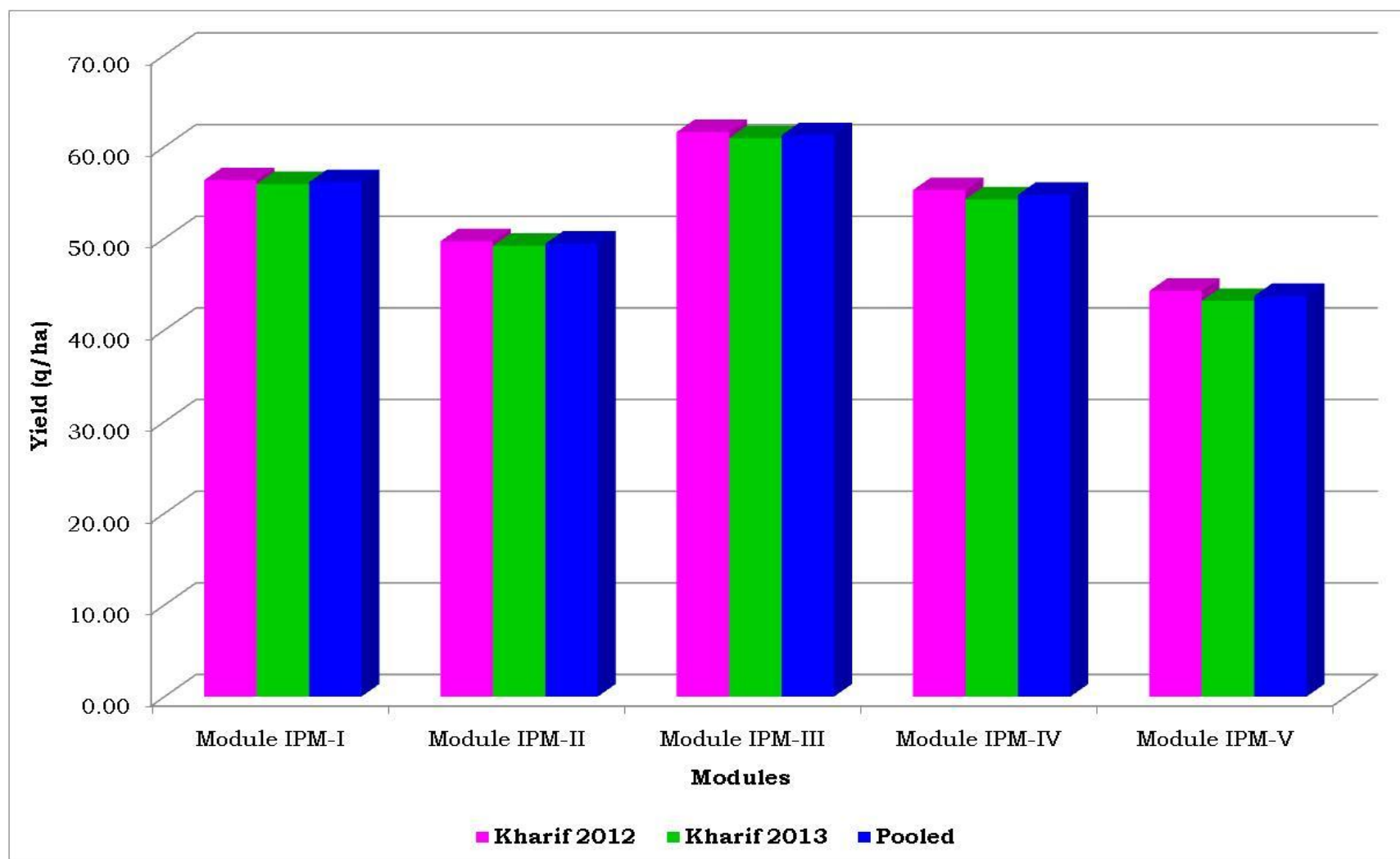


Fig. 49: Yield performance in different modules of rice

and Module IPM-IV (spot application) with 56.13 and 54.75 q/ha but showed similar results with each other. Module IPM-II (non-chemical based module) recorded 49.42 q/ha yield, but recorded significantly lower damage over Module IPM-V (farmer's practices) (43.71 q/ha). The yield interaction effect between modules and year was found non-significant, which revealed consistent performance of module treatments during the period of both years.

The overall results indicated that the Module IPM-III comprising of chemical and non-chemical based treatments *viz.*, application of carbofuran 3G @ 10 kg /1000 sq.m. in nursery at 15 days after sowing; installing pheromone traps @ 20 per ha starting from 15 DAT; field release of *Trichogramma chilonis* @ 1,00,000 parasitized *Corcyra* eggs/ha starting from 15 DAT; spray application of imidacloprid 17.8 SL @ 25 g a.i./ha and spray application of NSKE 5% at 25, 45 and 65 DAT found effective and also gave higher production applied against yellow stem borer, green leaf hopper, brown plant hopper, leaf folder and blue beetle.

The data on economics of the different modules (Table 53) showed that Module IPM-IV (spot application) gave highest benefit cost ratio of 11.35, followed by 4.43 Module IPM-III (chemical + non-chemical based module), 3.06 in Module IPM-I (chemical based module) and 2.02 in Module IPM-II (non-chemical based module) over Module IPM-V (farmer's practices).

Earlier, Maitri *et al.* (2007) revealed that the adoption of IPM package significantly enhanced rice grain in both improved and traditional varieties with highest average grain yield under improved practice. Improved practice also showed higher benefit: cost ratio with higher return over paid out cost. While, Mohapatra (2008) showed that Integrated Pest Management (IPM) plot recorded highest yield and cost benefit ratio in comparison to farmer's practice (FP) and Chemical based pest management (CBP) and Mahal *et al.* (2011) revealed that IPM model-I (Traps + chemical control) gave higher economic returns than IPM model-II (Traps + tricho-cards + chemical control). In another

experiment, Mishra and Sharma (2012) found that IPM schedule with eight components resulted in 34-39% increase in grain yield with mean increase of 36.79% over non-IPM plots as well as IPM module was found cost effectiveness over farmer's practice with 1:1.92 cost benefit ratio. All above mentioned research findings support and confirms the results found in current investigation regarding effectiveness of chemical and non-chemical based module.

Table 53: Economics in different modules of rice

Sr. No.	Name of module	Yield (q/ha)	Treatment Cost (Rs./ha)	Gross Income (Rs./ha)	Net Income (Rs./ha)	Net Profit over Farmer's practices (Rs./ha)	BCR
1.	Module IPM-I (Chemical based module)	56.13	5430	84195	78765	16620	1:3.06
2.	Module IPM -II (Non-chemical based module)	49.42	3973	74130	70158	8013	1:2.02
3.	Module IPM -III (Chemical + Non-chemical based module)	61.25	5473	91875	86403	24258	1:4.43
4.	Module IPM -IV (Spot application)	54.75	1618	82125	80507	18362	1:11.35
5.	Module IPM -V (Farmer's practices)	43.71	2610	64755	62145	--	--

▪ Price of Carbofuron 3G Rs. 90/kg, cartap hydrochloride 50 SP Rs. 1200/lit, imidachloprid 200 SL Rs. 3000/lit, pheromone traps Rs. 25/trap, pheromone lure Rs. 15/lure, Trichocards Rs. 15/card, NSKE (10000 ppm) Rs. 475/lit, imidacloprid 17.8 SL Rs. 2300/lit and Monocrotophos 36 SL Rs. 720/lit,.
 ▪ Labour charge Rs. 120/day and price of paddy Rs. 1500/q.

CHAPTER V

SUMMARY AND CONCLUSION

Rice, *Oryza sativa* Linnaeus is one of the most important crop and a staple food crop of India. Rice crop is affected by many insect species starting from seedling to maturity stage, out of which, about 20 insect pests have economic importance. Many integrated pest management practices are followed by farmers to overcome pest problems. The awareness regarding time of appearance of pest and period of its maximum activity helps the farmers to implement preventive and effective management practices. With this view, research work on the study of seasonal incidence, varietal screening and effectiveness of insecticides against yellow stem borer of paddy as well as evaluation of different management modules against rice pest complex under South Gujarat condition were carried out at Wheat Research Station Farm, N.A.U., Bardoli during the *Kharif* season of 2012 and 2013. The important conclusions derived from these investigations are summarized in this chapter.

5.1 Seasonal incidence of rice pest complex in relation to different methods of planting and its correlation with weather parameters

An experiment on the influence of different planting methods on succession of major pest of rice was conducted on rice field. This experiment was carried out with conventional and SRI method of paddy cultivation during consecutive *Kharif* season 2012 and 2013.

5.1.1 Rice yellow stem borer (*Scirpophaga incertulas* Wlk.):

Under conventional method of planting (Transplanting), yellow stem borer infestation with 0.66% dead hearts (DH) was appeared from first week of August and reached to its first peak of 5.58% DH during first week of September (36th SMW). Thereafter, infestation declined

gradually, but again increased during late stage of crop growth and found maximum (5.79% WEH) during 1st week of October.

In SRI method, the initiation of yellow stem borer incidence was observed from first week of August (32nd SMW) with 0.46% DH. Thereafter, the incidence increased and gained two peak; first of 4.19% DH in September (36th SMW) and second (4.93% WEH) at last week of September (39th SMW) and observed up to the harvest of crop. The infestation of stem borer was less in SRI method as compare to conventional method of planting.

The data of correlation co-efficient of yellow stem borer infestation with weather factors indicated non-significant results in conventional and SRI method. The results of both methods of planting indicated that the weather parameters had less influence on yellow stem borer damage as well as no difference found among both types of plantings, which justified that the stem borer activity concealed with plant phenology.

5.1.2 Green leaf hoppers (*Nephotettix virescens* Distal)

A. Conventional method (Transplanting):

Under conventional method of planting, rice green leaf hopper incidence data showed that the hill damage (0.29%) and the population of nymphs and adults (1.86/hill) was initiated from first week of September (36th SMW). This infestation and population of nymphs and adults showed increasing graph and the peak stage of per cent hill damage (2.39%) and the population (12.05/hill) was observed during first week of October (40th SMW). Thereafter, the incidence started to decline and observed till harvest of the crop (43rd SMW).

B. SRI method

The incidence data of rice green leaf hopper under SRI method of planting revealed that the hill damage (0.24%) and the population of nymphs and adults (1.14/hill) was initiated from first week of September (36th SMW). Thereafter, the peak stage of per cent hill damage (2.13%)

and population (8.73/hill) was observed during first week of October (40th SMW) and found till harvest of the crop (43rd SMW).

The amount of severity of the pest was seen at the flowering, dough and grain formation stages of the crop in conventional and SRI method of planting. However, the infestation level and the population of rice green leaf hopper under SRI method of planting was found comparatively less than conventional method.

The co-efficient correlation results revealed that the maximum temperature and bright sunshine hrs influenced positively the hill damage and the population of the rice green leaf hopper, while minimum temperature and relative humidity showed their negative effect. Rainfall did not showed any major corollary effect on the infestation of the green leaf hopper under conventional and SRI method of planting.

5.1.3 Brown plant hopper (*N. lugens*)

A. Conventional method (Transplanting)

Rice brown plant hopper recorded hill damage (0.44%) and the population of nymphs and adults (0.59/hill) from first week of September (36th SMW) in conventional method of planting. The infestation and population of nymphs and adults showed increasing graph and the peak stage of per cent hill damage (2.82%) and population (3.17/hill) was reached during first week of October (40th SMW) and observed till harvest of the crop (43rd SMW).

B. SRI method

The seasonal incidence of rice brown plant hopper under SRI method showed that the hill damage (0.21%) and the population of nymphs and adults (0.29/hill) was initiated from first week of September (36th SMW) and the peak stage of per cent hill damage (2.42%) and the population (2.54/hill) was observed during last week of September (39th SMW). Later on, the incidence was found till harvest of the crop (43rd SMW).

The amount of severity of the pest was seen at the reproductive stage of the crop in conventional and SRI method of planting. However, the infestation of rice brown plant hopper under SRI method of planting was found comparatively less than conventional planting method.

The coefficient correlation data revealed that the maximum temperature and bright sunshine hrs influenced the hill damage and the population of the rice brown plant hopper positively, while minimum temperature and relative humidity showed their effect negatively. Rainfall did not showed any major consequence on the incidence of the brown plant hopper under conventional and SRI method of planting.

5.1.4 Rice earhead bug (*Leptocorisa acuta* Stal.)

A. Conventional method (Transplanting):

Rice earhead bug data recorded in conventional method of planting revealed that the population of nymphs and adults (1.73/5 net sweep) was initiated from first week of September (36th SMW), which showed increasing chart after 36th SMW and the peak stage of the population (10.03/5 net sweep) was reached during first week of October (40th SMW). Thereafter, the incidence declined and observed till harvest of the crop (43rd SMW) with population of 5.95/5 net sweep.

B. SRI method

The seasonal incidence and the population data of rice earhead bug under SRI method of planting showed that the population of nymphs and adults (1.33/5 net sweep) was initiated from first week of September (36th SMW). Thereafter, the peak stage of the population (8.90/5 net sweep) was observed during first week of October (40th SMW) and found till harvest of the crop.

The amount of severity of the pest was seen at the milky stage of the crop and continues till hardening of grains both in conventional and SRI method of planting. These population results of rice earhead bug under both the method of rice cultivation showed that SRI method of

planting was found effective in lowering down the population of earhead bug as compared to conventional planting method.

The correlation data revealed that the maximum temperature and bright sunshine hrs positively controlled the population of the rice earhead bug, while minimum temperature and relative humidity showed their negative end results. Rainfall did not showed any major consequence on the population built up of the earhead bug, but caused positive relation impact under conventional and SRI method of planting.

5.1.5 Rice leaf folder (*C. medinalis*)

A. Conventional method (Transplanting):

The data on seasonal occurrence of leaf folder, *C. medinalis* revealed that the pest first appeared on 3rd week of August (34th SMW) with 0.77% leaf damage, continued till 3rd week of October (42nd SMW), when crop was almost nearer to maturity stage. The activity of the pest gradually increased and reached to peak level during 4th week of September (39th SMW) when leaf damage due to leaf folder was 2.30%.

B. SRI method

The seasonal incidence of leaf folder in SRI method revealed that 0.70% damaged leaves of rice leaf folder was initiated from 3rd week of August (34th SMW), which increased further and reached to its peak damage of 2.66% during 4th week of September (39th SMW) and reached to a zero level at the maturity of crop (43rd SMW).

The difference in leaf damage under planting method showed that the damage of leaf folder in SRI method was observed higher than conventional method (transplanting) of planting indicating less efficiency of SRI method to reduce the leaf folder infestation.

The correlation results under conventional and SRI method indicated that the weather parameters had less impact on leaf folder damage, which predicted that the damage was mainly concealed leaf folder activity with plant phenology.

5.1.6 Rice blue beetle (*L. pygmaea*)

A. Conventional method (Transplanting):

Rice blue beetle data recorded in conventional method of planting showed that the leaf damage (0.67%) and the population of adults (0.88/plant) was initiated from last week of July (31st SMW). This infestation and population of adults showed increasing graph and peak stage of per cent leaf damage (2.75%) and the population (2.41 adults/plant) was reached at last week of August (35th SMW) and found till last week of September (39th SMW).

B. SRI method

The seasonal incidence and the population data of rice blue beetle under SRI method of planting revealed that the leaf damage (0.69%) and the population of adults (0.75/plant) was initiated from last week of July (31st SMW). The peak stage of per cent leaf damage (2.30%) and the population (2.31 adults/plant) was observed at last week of August (35th SMW). Later on, the incidence started declining and ended at 39th SMW.

This intensity of the pest damage was seen during vegetative stage of the crop in conventional and SRI method of planting. However, SRI method of planting showed less infestation level and the population of rice blue beetle than conventional planting method.

The coefficient correlation data revealed that bright sunshine hrs affected the leaf damage and the population of the blue beetle negatively. Other weather parameters did not affect blue beetle damage and population under conventional and SRI method.

5.1.7 Rice sheath mite (*S. pinkii*)

A. Conventional method (Transplanting):

The results on number of sheath mites under conventional planting method showed that mite incidence was first appeared during the first week of September (35th SMW) with 0.80 mites/leaf sheath. It was gradually increased and reached its peak (18.04/leaf sheath) during

the first week of October (40th SMW). It was declined in the second week of October and recorded till harvest of the crop (43rd SMW).

B. SRI method

The results of sheath mite incidence under SRI planting method showed that the mite incidence was started from the first week of September (35th SMW) with 0.78 mites/leaf sheath. Further, it was gradually increased and reached its peak (11.95/leaf sheath) during the first week of October (40th SMW) and recorded till harvest of the crop (43rd SMW).

Thus, mite incidence was started from the booting stage of the crop, increased gradually and reached to peak during dough and milky stage of the crop under both the methods of planting *i.e.* conventional and SRI. The SRI method was found effective in controlling the mite population as compare to conventional method planting.

The pooled data of two years indicated that the maximum temperature and bright sunshine hrs positively affected the population of the rice sheath mite, while minimum temperature and relative humidity showed their negative end results. Rainfall did not showed any major consequence on the population built up of sheath mite.

5.1.8 Bio-Agents:

5.1.8.1 Spiders

A. Conventional method (Transplanting):

The data of spider population abundance indicated that the spider activity (0.50/hill) initiated from 4th week of July (31st SMW) and it continued till 4th week of October in conventional method of planting. The peak (4.36/hill) population of spider was attained during 1st week of October (40th SMW). Thereafter, spider population gradually decreased (4.36 to 2.53/hill) from 2nd week of October till harvest (43rd SMW).

B. SRI method

The spiders abundance data in SRI planting revealed that the spider activity (0.72/hill) was commenced from 4th week of July (31st SMW) and it continued till the harvest of the crop. The peak population of spiders (4.54/hill) was arrived during 1st week of October (40th SMW). Thereafter, spider population gradually declined from 2nd week of October till 4th week of October (43rd SMW).

The population activity of spider was observed higher under SRI method of planting as compared to conventional method. These may be due to the difference in plant population.

The correlation data indicated that the maximum temperature and bright sunshine hrs positively influenced the population of the spider, while minimum temperature showed it is negative impact on the population built up of spider.

5.1.8.2 Parasitoids

A. Egg parasitoid of rice yellow stem borer (*S. incertulas*)

Under conventional planting method, the egg parasitism of yellow stem borer by the Eulophid, *Tetrastichus schoenobii* was ranged between 12.50 to 33.04% with overall average of 15.56%. The peak parasitism by *T. schoenobii* was noticed up to 33.04 per cent during second week of September (37th SMW).

Under SRI method, the results revealed that the egg parasitism of yellow stem borer by *T. schoenobii* was ranged between 12.50 to 38.10% with overall average of 20.03%. The peak parasitism was noticed during second week of September (37th SMW). The activity of egg parasitoid was found better in SRI method as compare to conventional method.

B. Larval parasitoid of yellow stem borer (*S. incertulas*)

The larval parasitism results under conventional method showed that the parasitism of yellow stem borer by *Apanteles* sp. was ranged from 7.14 to 21.59% with overall average of 10.48%. The peak larval

parasitism by *Apanteles* sp. was observed 21.59 and 19.44 per cent during second week (37th SMW) and fourth week of September (39th SWM).

The data under SRI method revealed that the larval parasitism of yellow stem borer by *Apanteles* sp. was observed between 12.50 to 31.67% with overall average of 13.86%. The peak parasitism by parasitoid was noticed during second week of September (37th SMW) (31.67%) and fourth week of September (39th SWM) (28.57%).

C. Larval parasitoid of leaf folder (*C. medinalis*):

The results under conventional method showed that the larval parasitism of leaf folder by *Apanteles* sp. was ranged from 10.00 to 33.18% with overall average of 13.26%. The peak larval parasitism by *Apanteles* sp. was observed during first week of October (40th SWM).

The parasitism data under SRI method revealed that the larval parasitism of leaf folder by *Apanteles* sp. was observed between 8.33 to 27.88% with overall average of 12.18%. The peak parasitism by parasitoid was noticed during first week of October (40th SMW).

The activity of larval parasitoid in yellow stem borer and leaf folder was found higher in SRI method as compare to conventional method.

5.1.9 Succession of rice pest complex and bio-agents:

The data on population occurrence of rice pest complex under conventional and SRI planting method indicated similar type of trend in both the methods. The incidence of yellow stem borer appeared at early from tillering till reproductive stage. The intensity of stem borer was found fluctuating and showed two peak activities during heading and flowering stages. Among sucking pests, the movement of green leaf hopper and brown plant hopper was commenced during heading stage and was reached highest in flowering and milk grain stage. Their activity was noticed till the maturity of the crop. The population trend of earhead bug was observed from heading stage and caused maximum crop damage during milky stage and remains till maturity of the crop.

The leaf damage due to leaf folder was observed after stem elongation and booting stage, which reached highest during flowering stage and was recorded till dough grain stage. However, the infestation of blue beetle was noticed at early tillering stage of rice till flowering only. Their population remained highest during booting stage and then after declined. While in case of non-insect pest, sheath mite population was observed at late booting stage and reached at peak during flowering and milky stage of the crop and recorded till the harvest of the crop.

In case of natural enemies, spider population was observed with the initiation of the insect pest *i.e.* from tillering stage till the maturity of the rice crop. Their population activity was noticed more in number when there was higher pest pressure *i.e.* from flowering, milky and dough grain stage of the rice. Among parasitoids, egg parasitism of yellow stem borer was initiated after the start of yellow stem borer damage and reached highest during heading to flowering when there was high incidence of stem borer. Similar trend of larval parasitism of yellow stem borer was found with proportional in the larval population of the pest. The larval parasitism of leaf folder was started at booting stage when the leaf folder observed in the increasing trend and recorded highest parasitism during flowering and milky stage.

These population results of rice pest complex under both the methods of rice cultivation showed that SRI method of planting was found effective in lowering down the population of yellow stem borer, green leaf hopper, brown plant hopper, earhead bug, blue beetle and sheath mite as compared to conventional planting method except leaf folder. As well as the parasitoid activity was observed proportional to the population of the insect pests.

5.2 Varietal response against rice pest complex

Keeping in view of the economic importance of major insect pest complex of paddy, eighteen varieties were screened for their reaction against major insect pests including mites under field condition at

Wheat Research Station Farm, N.A.U., Bardoli during *Kharif* 2012 and 2013.

5.2.1 Yellow stem borer (*S. incertulas*):

The incidence of yellow stem borer was recorded at 30 and 50 days after transplanting (DAT) for number of dead hearts and 15 days before harvesting (DBH) at heading stage for number of white earheads and showed significant results among eighteen varieties. In the per cent dead heart infestation of yellow stem borer recorded at vegetative stage, GR-103, Gurjari and Masuri were found resistant (R) as these varieties registered DH index in between 1 to 10%, whereas five varieties *viz.* GNR-2, IR-22, Jaya, GNR-3 and GAR-2 were graded as moderately resistant (MR) to stem borer and exhibited DH index between 11 to 20%. Another five varieties *viz.* GAR-1, GR-7, NAUR-1, IR-28 and Narmada showed DH index between 21 to 30 per cent were categories in moderately susceptible (MS). Remaining varieties *i.e.* GR-102, GR-104 and GR-101 were graded as susceptible (S) against yellow stem borer DH index within 31 to 60%. GR-12 and GR-11 variety proved as highly susceptible (HS) and scored DH index more than 60%.

At heading stage, white earhead per cent infestation of the varieties *viz.*, Masuri, Gurjari and GR-103 were showed resistant (R) category as these varieties registered WEH index in between 1 to 5%. While, five varieties *viz.* GNR-2, GNR-3, GAR-2, IR-22 and Jaya were graded as moderately resistant (MR) to stem borer exhibited the WEH index between 6 and 10%. Another five varieties *viz.* GR-7, IR-28, GAR-1, Narmada and NAUR-1 were showed WEH index between 11 to 15% in moderately susceptible (MS) category. Remaining varieties *i.e.* GR-104, GR-102 and GR-101 were graded as susceptible (S) against yellow stem borer DH index within 16 to 25%. Variety GR-12 and GR-11 proved as highly susceptible (HS) and scored the WEH index of more than 26%.

5.2.2 Green leafhoppers (*N. virescens*):

The findings on per cent hill damaged due to green leaf hoppers indicated significant differences among evaluated varieties and on the basis of corrected mortality index basis, GR-101, GR-102, GR-103, and GR-104 found resistant and recorded per cent hill damage between 1 to 10%. While, GNR-2, GAR-1, Narmada and GR-7 and were categories into moderately resistant with hill damage between 11 to 25%. Other varieties *viz.*, NAUR-1, GNR-3, GAR-2, IR-22 and GR-12 were found moderately susceptible showed hill damage between 26 to 50%. Variety IR-28, GR-11 and Masuri were recorded susceptible with hill damage between 51 to 75%, whereas, Gurjari and Jaya were grouped into the highly susceptible category and showed hill damage from 76 to 100%.

5.2.3 Brown plant hoppers (*N. lugens*):

The data on per cent hill damaged due to brown plant hoppers showed significant results. Among 18 varieties and indicated that GR-101, GR-102, GR-103, GR-104 considered as resistant with 1 to 10% hill damage, while other 5 varieties *viz.*, GNR-3, GNR-2, GR-7, GAR-1 and Narmada showed 11 to 25% hill infestation considered as moderately resistant. The varieties that recorded hill damage between 26 to 50% were NAUR-1, GAR-2, GR-12 and IR-22 considered as moderately susceptible. Varieties *viz.*, IR-28, GR-11 and Masuri considered as susceptible with 51 to 75% hill damage and the two varieties *viz.*, Jaya and Gurjari considered as highly susceptible with more than 76% hill damage.

5.2.4 Earhead bug (*L. acuta*)

The data on per cent damaged grains per panicle due to earhead bug revealed significant results among evaluated varieties and indicated that the varieties *viz.*, GR-104, GAR-1, GNR-3, IR-22, GR-102 and GAR-2 found moderately resistant with 4-7% grain damage. Whereas, the other 10 varieties *i.e.* GNR-2, GR-12, GR-103, GR-7, GR-101, GR-11, Gurjari, Narmada, NAUR-1 and Masuri were categorized into moderately

susceptible group that recorded 8 to 15% grain damage. The variety IR-28 found susceptible with 16-25% grain damage, while Jaya was categories into highly susceptible with more than 26% grain damage.

5.2.5 Leaf folder (*C. medinalis*)

The findings on per cent damaged leaves due to leaf folder showed significant differences in eighteen varieties and GR-102, GR-103 considered as resistant with 1 to 10% leaf damage, while 8 varieties considered as moderately resistant are GNR-3, Gurjari, IR-22, GNR-2, NAUR-1, IR-28, GAR-1 and GR-7 showed leaf infestation ranged between 11 to 20%. The varieties recorded leaf damage between 21 to 35% were Narmada, GAR-2 and GR-11 and were considered as moderately susceptible. The variety GR-101 found susceptible with leaf damage between 36-50%. However, varieties considered as highly susceptible were GR-12, Jaya, GR-104 and Masuri with leaf damage between 51 to 100%.

5.2.6 Blue Beetle (*L. pygmaea*):

The results on per cent leaf damage due to blue beetle recorded significant results and revealed that 7 varieties *viz.*, GAR-1, GR-102, IR-22, GAR-2, GR-103, GNR-2 and GR-104 are considered as resistant with 1 to 10% leaf damage, while 4 varieties *viz.*, GNR-3, GR-7, IR-12 and IR-28 showed leaf infestation ranged between 11 to 25% considered as moderately resistant. The varieties recorded leaf damage between 26 to 50% are GR-101, Narmada and NAUR-1 considered as moderately susceptible. However, varieties *viz.*, Masuri, Gurjari and Jaya considered as susceptible with leaf damage between 51 to 75%, while the variety Jaya is considered as highly susceptible with 100% leaf damage.

5.2.7 Sheath mite (*S. spinki*)

The population data of mites revealed significant differences in eighteen varieties and only 2 varieties *i.e.* Masuri and IR-28 are found promising varieties, while other 8 varieties which considered as less susceptible are GR-101, GNR-3, GR-104, GR-102, GAR-1, GR-7 and GR-

11 showed less infestation. The six varieties recorded moderate population and grouped into moderately susceptible are IR-22, GR-12, GR-103, Narmada, GNR-2 and NAUR-1. However, varieties considered as highly susceptible are Gurjari and Jaya.

5.3 Effectiveness of insecticides against rice yellow stem borer:

The average data on per cent dead hearts due to yellow stem borer was recorded at 3, 7 and 10 days after first and second spray and revealed significant results at each level. On first spray, the minimum damage was recorded in treatment fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃) and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) and were found at par with each other, but showed significantly lower damage over control.

After second spray, the similar trend of insecticides performance against yellow stem borer was observed with significant data. The minimum damage was recorded fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃) and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) were found at par with each other and also showed significantly lower damage than control.

The yield data of paddy obtained under influence of various insecticidal treatments showed significant findings. The average highest yield of 59.04 q/ha was obtained in treatment fipronil 0.3 G (T₂), followed by spinosad 45 SC (T₃) with 57.21 q/ha yield and they were at par with each other. The other treatments *viz.*, profenophos 50 EC (T₁) and cartap hydrochloride (T₄) recorded 51.71 and 50.33 q/ha yield, which were found at par with each other and also showed significantly higher yield over control (43.79 q/ha).

5.4 Evaluation different modules for management of rice pest complex

The results after evaluation of different modules comprising various IPM practices against yellow stem borer, green leaf hopper, brown plant hopper, leaf folder and blue beetle at different interval showed significant results.

5.4.1 Yellow stem borer (*S. incertulas*)

The different modules were tested against yellow stem borer and results were recorded at 30, 50, 60 and 70 days after transplanting (DAT) and the results showed significant differences among different modules. Significantly minimum dead heart damage was recorded in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module). The next effective module was Module IPM-II (non-chemical based module) and found comparable with Module IPM-IV (spot application). The highest dead heart damage was recorded in Module IPM-V (farmer's practices).

5.4.2 Green leafhopper (*N. virescens*)

The performance of different modules followed against green leafhopper was estimated at 50, 60 and 70 DAT and the results showed significant findings. The lowest hill damage was found in Module IPM-III (chemical + non-chemical based module) and showed comparable results with Module IPM-I (chemical based module). Significantly effective performance was also found in Module IPM-IV (spot application), followed by Module IPM-II (non-chemical based module). The highest hill damage was found in Module IPM-V (farmer's practices).

5.4.3 Brown plant hopper (*N. lugens*)

The effectiveness of different modules against brown plant hopper was tested at 50, 60 and 70 DAT and showed significant results. The lowest hill damage was found in Module IPM-III (chemical + non-chemical based module), but found at par with Module IPM-I (chemical based module). The next effective module was Module IPM-IV (spot

application), followed by Module IPM-II (non-chemical based module). The highest hill damage was found in Module IPM-V (farmer's practices).

5.4.4 Leaf Folder (*C. medinalis*)

The results on leaf damage caused due to leaf folder at 50, 60 and 70 DAT under different modules recorded significant results. Significantly lowest leaf damage was found in Module IPM-III (chemical + non-chemical based module), followed by Module IPM-I (chemical based module). The next effective module was Module IPM-IV (spot application), but showed similar results with Module IPM-I. Module IPM-II (non-chemical based module), but recorded significantly lower damage over Module IPM-V (farmer's practices).

5.4.5 Blue beetle (*L. pygmaea*)

The data on leaf damage caused due to blue beetle under different modules recorded at 30, 50 and 60 DAT showed significant results. The significantly lowest leaf damage was found in Module IPM-III (chemical + non-chemical based module). The next best modules were Module IPM-I (chemical based module), Module IPM-IV (spot application) and Module IPM-II (non-chemical based module), which recorded lower leaf damage due to blue beetle. All the modules showed significantly lower damage than Module IPM-V (farmer's practices). The infestation caused due to different insect pests in all IPM Module showed decreasing trend in successive period.

5.4.6 Yield and Economics

The yield performance of different modules revealed significant results. The significantly highest yield (61.25 q/ha) was found in Module IPM-III (chemical + non-chemical based module). The next effective modules were Module IPM-I (chemical based module) and Module IPM-IV (spot application) with 56.13 and 54.75 q/ha but showed similar results with each other. Module IPM-II (non-chemical based module) recorded 49.42 q/ha yield, but recorded significantly higher yield over Module IPM-V (farmer's practices) (43.71 q/ha).

The data on economics of the different modules showed that Module IPM-IV (spot application) gave highest benefit cost ratio of 11.35, followed by 4.43 Module IPM-III (chemical + non-chemical based module), 3.06 in Module IPM-I (chemical based module) and 2.02 in Module IPM-II (non-chemical based module) over Module IPM-V (farmer's practices).

CONCLUSION:

From present findings following conclusion can be drawn.

- ❖ The succession of major insect pest of rice noticed with the beginning of the season *i.e.* from tillering stage with more or less population fluctuation till the maturity of the rice crop. Similarly, activity of natural enemies was also proportional to the pest incidence.
- ❖ Thus, damage to the paddy crop caused by different pest *viz.*, yellow stem borer, green leaf hopper, brown plant hopper, earhead bug, leaf folder and blue beetle can be effectively managed by adopting SRI (System of Rice Intensification) planting methods. While in case of conventional method of transplanting was found less effective. However, damage of leaf folder can be effectively managed by adopting the conventional transplanting method.
- ❖ To avoid the further increase of the pest, constant supervision of pest is of prime importance to suppress the population to minimize the cost of insecticides. For monitoring point of view, heading and flowerings stages were critical for yellow stem borer; flowering and milk grain stages were vital for green leaf hopper, brown plant hopper, earhead bug, leaf folder and sheath mite as well as booting stage was important for blue beetle.
- ❖ It necessary to avoid excess and indiscriminative use of insecticides to conserve natural enemies in field, which appears on the crop after the initiation of the pest incidence.
- ❖ On the basis of the damage caused by different pests of rice, Gurjari, Masuri, GNR-3 and GR-103 are resistant/moderately resistant

varieties against yellow stem borer and GR-11, GR-104, GR-104 and GR-12 are susceptible/moderately susceptible varieties. Whereas, among foliage feeders, GR-103, GR-102, GR-101, GAR-1 and GAR-2 are resistant/moderately resistant varieties, while Jaya, Gurjari, GR-11, Masuri and NAUR-1 are susceptible/moderately susceptible varieties. Keeping these varieties in view for further research work, the biochemical analysis of different varieties of rice which are responsible for attraction of major insect towards them should be carried out.

- ❖ In case of advance stage of yellow stem borer damage, application of two spray of fipronil 0.3 G or spinosad 45 SC minimize infestation.
- ❖ For insect pest complex management in rice, Module IPM-III comprising chemical and non-chemical based components of insect pest management or Module IPM-I (Application of carbofuran 3G @ 10 kg /1000 sq.m. in nursery at 15 days after sowing; pheromone mediated mass trapping by installing pheromone traps 5 mg lure @ 20 per ha with changing of lures every 20-25 days, starting from 15 DAT against stem borer; field release of *Trichogramma chilonis* @ 1,00,000 parasitized *Corcyra* eggs/ha, 5-6 times starting from 15 DAT against leaf folder; spray application of imidacloprid 17.8 SL @ 25 g a.i. (150 ml formulated product) per ha against plant hoppers and spray application of NSKE 5% at 25, 45 and 65 DAT against yellow stem borer) constituting chemical treatments should be applied at various calendar weeks for yellow stem borer, green leaf hopper, brown plant hopper, leaf folder and blue beetle.

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* Original not seen

Appendix – I

Standard Meteorological weekly weather data of *kharif* 2012

Month	Standard Meteorological weekly	Temperature (°C)		Relative Humidity (%)	Total Rainfall (mm)	Bright Sunshine hrs
		Max.	Min.			
July	28	30.71	25.50	96.79	92.00	0.00
	29	31.36	25.86	91.43	34.20	0.00
	30	30.29	26.07	92.50	9.40	0.00
	31	30.00	25.36	90.36	18.80	0.00
August	32	29.14	24.86	95.00	45.60	0.00
	33	30.14	24.64	92.50	11.60	0.00
	34	30.57	24.07	93.21	29.80	0.00
	35	31.43	25.07	93.57	47.20	0.00
September	36	28.79	24.43	94.64	276.20	0.00
	37	29.50	23.79	96.07	90.40	0.43
	38	30.79	23.79	92.86	23.80	2.14
	39	32.14	22.64	91.43	37.80	3.09
October	40	33.86	23.29	92.14	27.20	5.35
	41	35.29	22.36	87.14	0.00	7.65
	42	35.56	21.36	78.21	0.00	8.87
	43	35.07	20.50	75.00	0.00	8.28

Appendix – II

Standard Meteorological weekly weather data of *kharif* 2013

Month	Standard Meteorological weekly	Temperature (°C)		Relative Humidity (%)	Total Rainfall (mm)	Bright Sunshine hrs
		Max.	Min.			
July	28	28.57	24.14	93.57	134.80	0.00
	29	28.93	24.57	96.43	187.00	0.00
	30	27.51	24.29	96.07	244.00	0.00
	31	28.57	23.86	96.43	140.50	0.00
August	32	29.43	24.00	94.64	84.80	0.00
	33	29.57	24.29	94.83	46.00	0.00
	34	28.69	24.01	93.40	31.60	0.00
	35	30.29	23.69	94.65	46.00	0.00
September	36	30.39	22.89	89.61	0.00	3.65
	37	32.50	22.43	91.14	110.80	5.61
	38	30.75	24.21	93.14	133.60	3.85
	39	29.43	22.93	89.71	406.00	4.01
October	40	30.79	24.43	90.66	47.80	3.69
	41	30.79	23.14	92.43	517.80	4.12
	42	34.29	23.93	94.95	0.00	8.51
	43	34.50	19.86	80.73	0.00	9.09

C E R T I F I C A T E

This is to certify that I have no objection to supply one copy of any part of this thesis at a time to any scientist through reprographic process for rendering reference services in a library or documentation centre.

Place: Navsari

Date: 2nd June, 2014

(Kakde A. M.)